FORMERLY THE SPICE MILL

COFFEE & TEA INDUSTRIES

81st YEAR NOVEMBER, 1958

C. E. BICKFORD & CO.
COFFEE BROKERS
AND AGENTS
Since 1886

NEW YORK
120 Wall Street

NEW ORLEANS
427 Gravier St.

COLOMBIA . . .

home of PREMIUM coffee

The cherry is picked by hand in Colombia, for only the deep red cherry must be harvested. In order to ensure crops of uniform ripeness and quality, the picker returns to the tree many times during the harvesting season. Such selective harvesting is one of the factors reflected in the superior aroma and flavor of Colombia's premium coffees. It is one of the many reasons why coffee from Colombia is the best in the world.

National Federation of Coffee Growers of Colombia

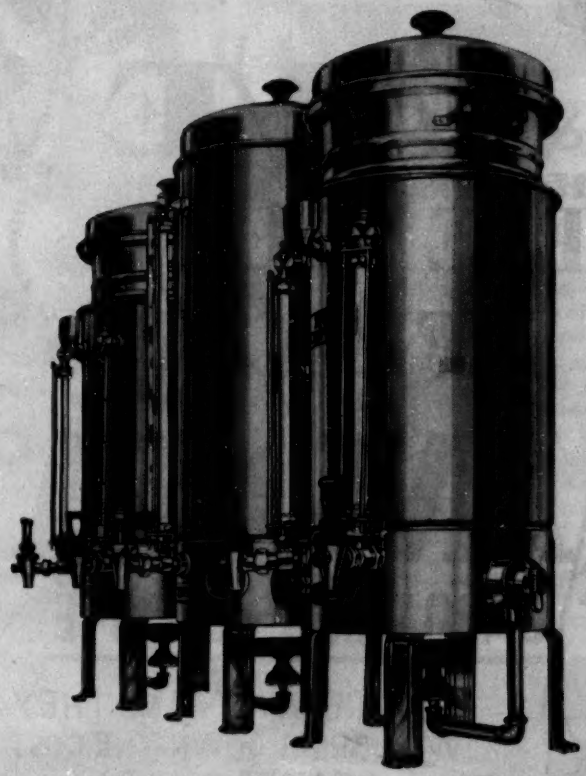
120 WALL STREET, NEW YORK 5, N. Y.

Member of

Pan-American Coffee Bureau

NEW CECILWARE

completely modern inside and out

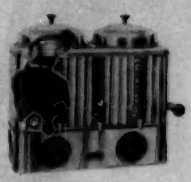


series '61 de luxe urn batteries

with these exclusive features

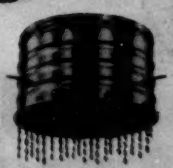
- **Gridded Riser***
- **Panel construction**
- **Front drain on coffee liners**
- **Dial thermometer**
- **Self-closing, easy to clean faucets**
- **Seam welded urn seams**
- **Adjustable water gauge marker**
- **High powered heating unit**
- **Robertshaw automatic thermostats**
- **Prices start at $450.00**

Everything you've ever hoped for in urn batteries has been included in the beautiful new Cecilware Series '61. Time saving, economical and efficient, they bring added prestige to your counter or kitchen . . . And brew the most delicious coffee you ever tasted!



America's leading urns – These distinctive new stainless steel batteries are worthy companions to the Cecilware Series '61 urns – nationally recognized as the most original and practical urns in use today. Whether you require a compact single urn or a large battery, Cecilware has the *right* equipment for your operation. See the complete line at your dealer, and write for special offer described at left.

* COFFEE BREWING INSTITUTE'S URN BREWING METHOD



The Gridded Riser is Cecilware's new coffee basket that utilizes a standard coffee bag and allows you to brew better coffee, faster and economically. We've just published an illustrated booklet describing this important new method of brewing coffee as recommended by the Coffee Brewing Institute. For your copy, plus our latest catalog, please send 25c to cover cost of postage and handling.

Coffee by the gallon

CECILWARE-COMMODORE PRODUCTS CORPORATION

Since 1911, more than a million Cecilware-Commodore products in use

199 Lafayette Street, New York 12, N. Y.

NOW

MORE THAN EVER IS THE TIME TO SAVE WITH PORTUGUESE WEST AFRICANS

ANGOLA

CABO VERDE • S. TOMÉ

THEY ARE SWEET AND THEY WILL BRING DOWN THE COST OF YOUR BLENDS

JUNTA DE EXPORTAÇÃO DO CAFÉ ☆

HEAD OFFICE: RUA AUGUSTA - 27 - LISBON PORTUGAL

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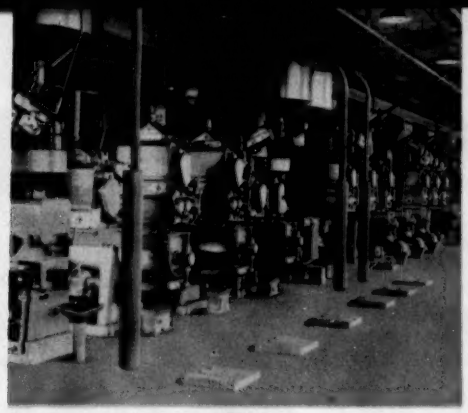
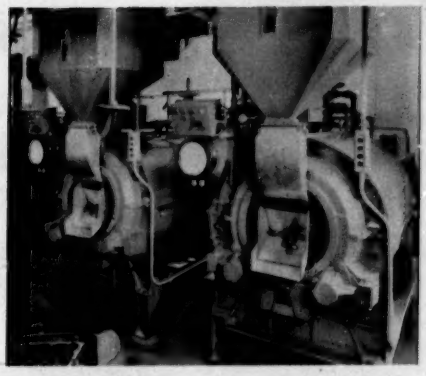
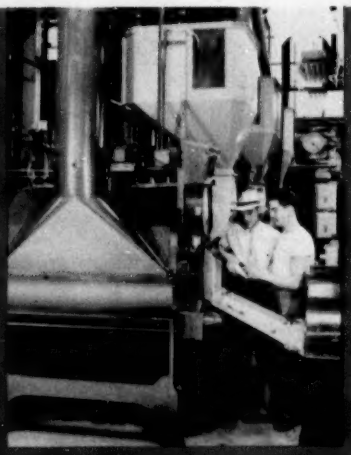


The world's largest coffee grinding installation is equipped exclusively with Gump Coffee Granulizers. This firm has purchased more than 50 Gump Coffee Granulizers.



Two Gump Ray-Nox Roasters in a west coast installation produce uniform roasts of high cupping quality.



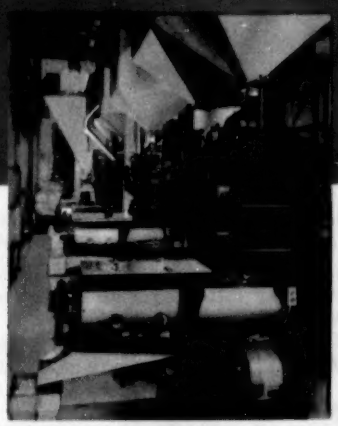
MODERN COFFEE PLANT
Engineering and Equipment

Build Coffee Sales . . . Cut Production Costs

Whether you want to design and equip a complete plant—modernize or expand just one department—or select a single piece of new equipment . . . Gump engineers can make your planning easier, your installation more efficient.

Gump engineers have worked with hundreds of coffee plants, of all sizes and with widely varied requirements. Their seasoned experience, combined with the Gump line of modern coffee plant equipment, offers the coffee industry a complete service for coffee production requirements.

Gump Coffee Plant Equipment is designed to provide positive quality control, and to achieve peak efficiency and smooth production flow throughout the coffee plant. This equipment is illustrated and briefly described on the following pages. For more detailed data – and Gump Engineering Service – contact the B. F. Gump Co., 1325 S. Cicero Ave., Chicago 50, Illinois, U.S.A.



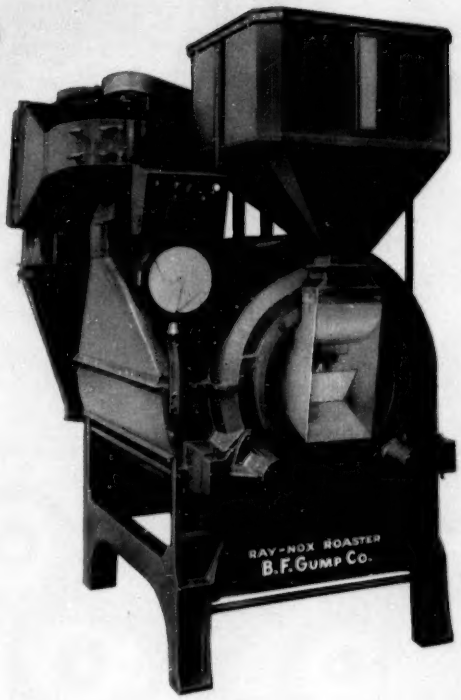
A Midwestern regional roaster operates six Gump Coffee Granulizers, purchased over a period of twenty years.

Three Bar-Nun Bag Feeders, Openers and Weighers increase production and reduce costs in the packaging department of a Canadian plant.

B. F. GUMP CO. 1325 S. CICERO AVENUE, CHICAGO 50, ILLINOIS, U.S.A.

RAY-NOX COFFEE ROASTERS

set new coffee roasting standards
in cup and keeping qualities
in roasting economies
in operating convenience



The method of roasting utilized in the Ray-Nox Roaster brings the various blended coffees to full development simultaneously. A scientific balance of both clean, penetrating radiant heat and convected heat—exclusive with the Ray-Nox Roaster—appears to develop the beans from the center outward, producing a highly uniform, good glossy finish, free of tipping. The coffee grinds to the same color as the roasted bean. In addition, roasts are uniform from batch to batch. The Duo-Set Controllers, available with Ray-Nox Roasters, provide the closest possible control over the roasts. Roasts are also uniform in bulk density—a factor in vacuum can packing.

Each roast is sweet, clean and bright. There is no recirculation of exhaust gases in the Ray-Nox Roaster—and the roasting cylinder, flights and canopy are constructed of stainless steel to protect the coffee from metallic contamination.

Users advise that roasts from Gump Ray-Nox Roasters excel in maximum retention of acidity, bouquet, and winey character of higher grade coffees, and that lower priced coffees are upgraded. Tests from the "cold cup" clearly show the more lasting freshness of the roasts.

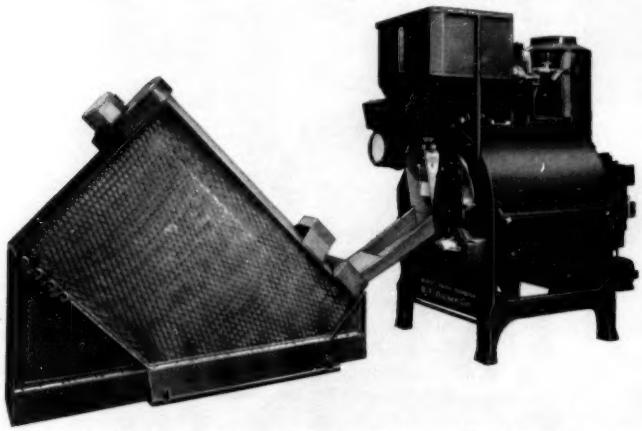
You, too, will find that Ray-Nox Roasters will result in benefits in the cup and in production economies in your plant.

Easy Cleaning—Operating Convenience

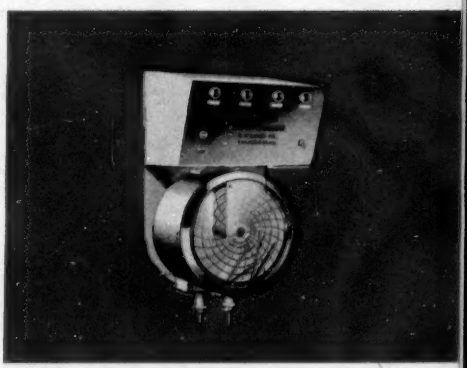
The roasting cylinder is readily accessible, as the outer housing can be quickly removed in sections. The stainless steel roasting zone is easily wiped clean of dirt and roasting by-products. All moving parts are shielded from heat and dirt, for trouble-free operation and longer life. Lubrication requirements are simple. Safety devices are all of the latest design and Factory Mutual approved. A choice of optional control accessories provides for the degree of automatic operation preferred in each installation.

Construction Features

The rigid, box type, main frame and its sub-assemblies are made of heavy-section castings machined to precise machine tool tolerances. All bearings are of the anti-friction, sealed type and are located outside the roaster housing. Gump Ray-Nox Roasters are supplied with 3 HP ball bearing, gearhead, splash-proof motor and double roller chain drive and guard; with self-contained, motor driven fan and chaff collector.



Above: The Gump Ray-Nox Roaster with the Ideal Vertical-Twin Cooler. This Gump-built combination produces roasts of enhanced cup and keeping qualities, with greater convenience, at lower cost. Features of the Ideal Coffee Cooler are described on the next page.



DUO-SET Recording Thermometers and Controls

Gump Ray-Nox Roasters are available with the following choice of control accessories.

1. Indicating or recording thermometer.
2. Recording thermometer with visual signaling device.
3. DUO-SET recording thermometer and controller, for automatic control of gas and quench only.
4. DUO-SET recording thermometer and controller, for automatic control of gas and quench on and off, door, cooler and feed regulating hopper—providing a completely automatic roasting and cooling cycle.

B. F. GUMP CO., Chicago 50, Illinois

cool coffee to room temperature rapidly and efficiently

IDEAL COFFEE COOLERS

The Ideal Vertical-Twin Coffee Cooler will cool a full four-bag roast—uniformly throughout the batch—to room temperature in three to five minutes, depending on amount of quench and air suction provided.

The coffee is received direct from roasters and is rapidly elevated into twin vertical coffee cooling zones formed by stainless steel perforated screen sides and separated by an air suction area. Air is drawn through the two thin layers of coffee simultaneously, to cool the coffee quickly and uniformly. Air guide fins are provided to restrict the air flow to the desired area when a less than full capacity load is being cooled.

There is no breakage of the whole beans in the Ideal Cooler. The Ideal is a space saver, leaving plenty of room to work around it. *Stainless steel* construction of all sheet metal parts coming into contact with the coffee prevents metallic contamination of the roast, eliminates rusting, and makes cleaning the cooler "no problem."

Users realize the improved cupping quality of rapid cooling and the economies of no shrinkage from loss due to breakage in the cooler.

The Ideal Cooler is self-contained, and is furnished complete with motor, ready to connect with air suction system. Motor driven suction fan can be supplied as additional equipment if required.

combine modern air flow principles with convenient adjustments

IDEAL STONERS

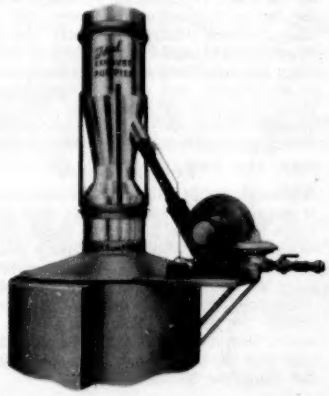
Ideal Stoners are recommended for removing from the roasted whole bean coffee, stones or pieces of metal or other foreign objects heavier than the coffee. The modern air flow principle and convenient adjustments incorporated in the Ideal Stoner assure a thorough separation of the coffee from heavier materials and without breakage of the whole beans.

The receiving boot is equipped with a permanent magnet, which removes particles of ferrous metal from the coffee. Stones and other objects that are heavier than the coffee beans also remain in the Stoner boot. The coffee beans are elevated by suction to the Stoner hopper which is equipped with a curvilinear receiving chamber and ample expansion area for thorough separation of coffee and air. Hopper capacity is 1000 pounds.

Ideal Stoners are available in three sizes, for installations of up to 20, 30 or 45 feet. They are furnished complete with fan, V-belt drive and motor with magnetic starter and push button station. Manual controls for adjusting air volume and airlock discharge gate are included as standard equipment.

efficient and economical smoke reducing units

IDEAL EXHAUST PURIFIERS



The Gump Ideal Exhaust Purifier offers a practical and economical method of controlling and greatly reducing the smoke content of roaster exhausts. It has been approved by air pollution boards in several metropolitan areas.

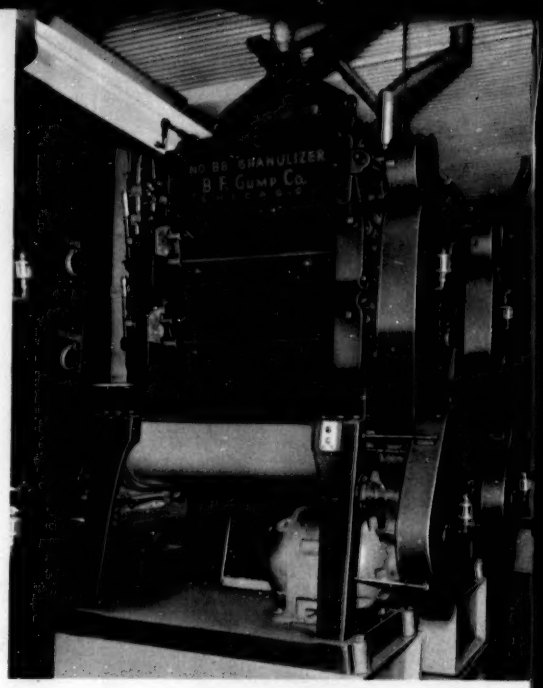
Smoke from the chaff collector is discharged through the Venturi passage of the Exhaust Purifier, where it is subjected to high temperature flame. Efficiency is not affected by quench steam or moisture content of exhaust. A unique, simplified unit, the Ideal has exceptionally low operating and maintenance costs and the consumption of gas is increased by only about fifteen per cent per roast.

The Ideal Exhaust Purifier is furnished complete with stainless steel Venturi chamber, and motorized air-gas mixing equipment, nozzle, controls mounted on plate, and with support frame for mounting on the chaff collector, as illustrated. Available for existing roasting equipment, or as part of a new Ray-Nox Roaster installation.

B. F. GUMP CO., Chicago 50, Illinois

GUMP COFFEE GRANULIZERS

produce clean-cut, consistently uniform "Preferred Grinds"... at lower operating cost ... with more years of trouble-free service.



Uniformly ground coffee . . . coffee that will brew the same day in and day out . . . with consistently fine flavor and aroma . . . is an acknowledged must in building and retaining customer good will. For producing those clean, consistently uniform, full flavored grinds—with unfailing mechanical precision—the great majority of the coffee trade in the United States, and many coffee plants throughout the world, depend exclusively on Gump Coffee Granulizers.

Gump Coffee Granulizers produce any commercial size grind from fine to coarse regular by instant single or double lever control, and any grind previously produced can be exactly duplicated at will. In addition, compact modern design and sturdy construction assure simplified operation and lower production costs. A wide range of sizes and models provides a unit suited to any coffee grinding requirement.

Important Features that mean Sharp, Uniform Grinds at Low Cost

All-Roll, Gradual Reduction, Sectional Grinding Head

GUMP'S original method of producing clean-cut, uniform granulations employs specially developed corrugated rolls in series for the gradual reduction of coffee. The Head is in two or three sections. Models Nos. 66E, 77E and 88E utilize two sections: the top section containing double reduction breaker rolls, and the center section containing granulating rolls, for the production of a full range of regular and drip grinds. Models Nos. 666E, 777E and 888E also include the third or fine grind section, for producing the complete range of commercial grinds, including the finest. Sections are replaceable individually in the Gump Exchange Head Plan, explained below.

Gump Granulizer Grinding Heads are also available as self-contained units, without the Granulizing Chamber, for the production of coarse grinds frequently preferred in soluble coffee preparation. For this use, they are supplied mounted on channel iron base, complete with motor, drive and guard.

Stainless Steel Mixing Chamber

Protects the flavor and aroma of Granulized Coffee from metallic contamination, as coffee and chaff are mixed together in the exclusive, stainless steel "Granulizing Chamber."

Positive Grind Control

Micrometer type of grind set adjustment provides a limitless choice of granulation sizes, each one reproducible at will. Grind setting cannot slip while the Gump Granulizer is in operation; maintains consistently even the most rigid sieve analysis specifications.

Accurate Capacity Regulator

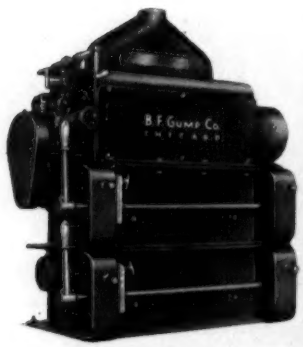
Correctly regulates capacity in keeping with the size grind being produced and uniformly distributes feed over the entire surface of the cutting rolls.

Easy to Clean and Adjust

Designed for easy cleaning, when changing grind size or quality of coffee. All parts readily accessible for adjustment.

Modern, Heavy-duty Construction

Compact, sturdily constructed machines that win the engineer's approval and the production manager's preference. Equipped with smooth running ball and roller bearings to provide maximum production with minimum power, and with powerful, flexible Hexaco reverse chain drive.



The buyer of a Gump Coffee Granulizer has available, in addition to an excellent machine, the economical and original Gump Exchange Head Service.

THE GUMP EXCHANGE HEAD PLAN

How It Works

When, from normal use, the cutting elements of a Granulizer grinding head require sharpening, the user merely orders an Exchange Head, or, with Style E Granulizers, any section he requires, from the B. F. Gump Co. A completely reconditioned, guaranteed head or section is shipped to the user, and he returns the worn unit in the same crate for credit. For this service, there is a reasonable charge to cover reconditioning and replacement of worn parts.

Advantages to Users

Under this Exchange Head Plan, users need not invest in extra grinding parts, or lose more than a few hours of production. The Granulizer is restored to "like-new" grinding condition, with measurable savings in money and time.

In addition, users have the assurance that the rolls have been correctly recorrugated and all worn parts replaced with genuine factory parts. All work is performed in our own shops by the same experienced workmen who build the heads originally, and worn rolls are replaced when reduced beyond usable size. Minor mechanical improvements developed since the head was originally built are added at no charge, and major improvements are made available at reasonable cost. The Exchange Head carries the unconditionable Gump guarantee to perform "as good as new."

Foreign Users

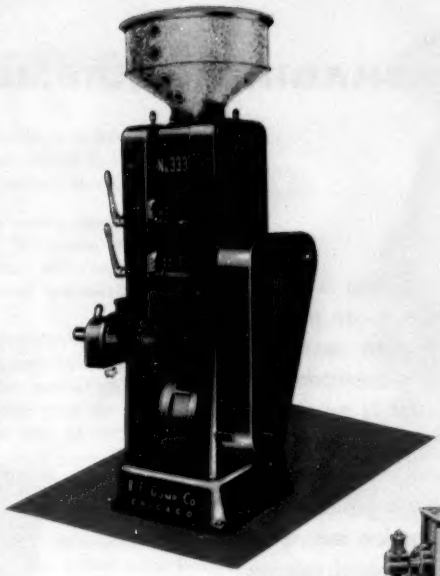
Although import duties and restrictions make it impractical for most foreign users to participate fully in the Exchange Head Plan, they can still take advantage of Gump guaranteed service. At the time of original purchase, or later when required, a foreign company can order one additional complete grinding head. When the rolls in the head in use become worn, they replace it with the standby head, and ship the worn head to the B. F. Gump Co. for complete reconditioning.

The Complete Line of

GUMP

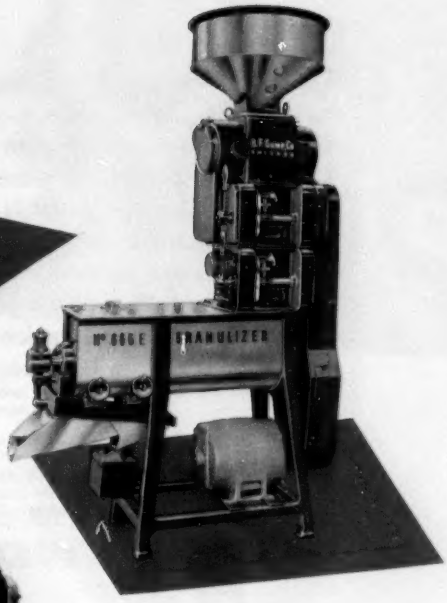
COFFEE GRANULIZERS

provides a model exactly suited to your needs



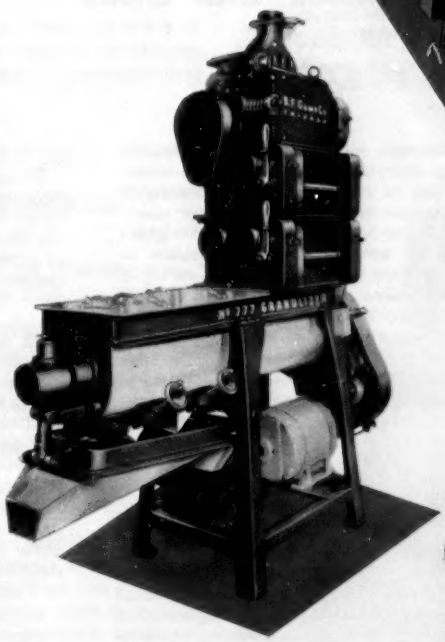
No. 333 GUMP COFFEE GRANULIZER. Produces fine, drip and regular grinds, in capacities up to 700 pounds per hour. The No. 333 is recommended for suppliers to the hotel and restaurant trade, especially for the production of fine and drip grinds superior in cupping quality to those produced on plate mills; also as a standby unit, for producing special orders in batches as small as 10 pounds.

No. 33 GUMP COFFEE GRANULIZER is the same model as the No. 333, except without the extra set of finishing rolls; produces fine and drip grinds only. Additional section can be added at any time, to convert to No. 333 model.



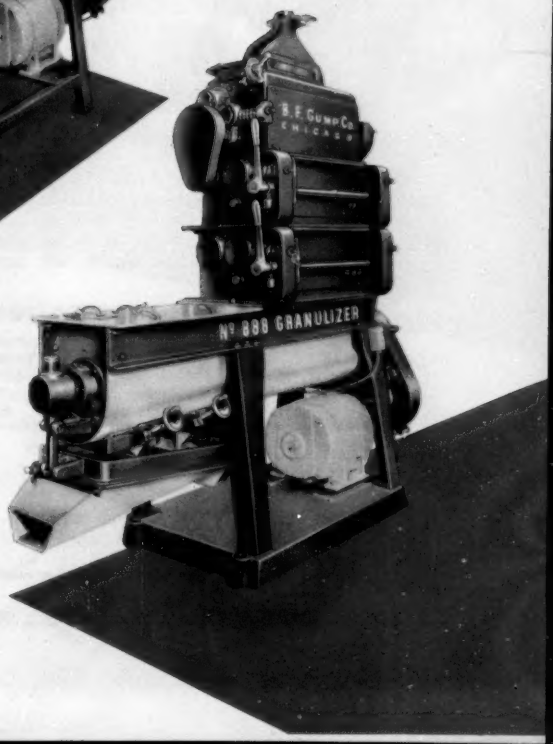
No. 666E GUMP COFFEE GRANULIZER. Produces the complete range of fine, drip and regular grinds, in capacities up to 1000 pounds per hour. The No. 666E is the preferred production unit for a "one-floor, one-man" grinding and packaging plant. Also often purchased for standby capacity for special runs in larger plants.

No. 66E GUMP COFFEE GRANULIZER is the same model as the No. 666E, except without the third or fine grind section; produces drip and regular grinds only. Fine grind section can be added at any time, to convert to No. 666E model.



No. 777E GUMP COFFEE GRANULIZER. Produces the complete range of fine, drip and regular grinds, in capacities up to 2000 pounds per hour. Its complete range of commercial grinds and substantial capacity qualify the No. 777E as a "one-machine" grinding plant. It synchronizes with packaging equipment having speeds of 25 to 30 one-pound packages per minute.

No. 77E GUMP COFFEE GRANULIZER is the same model as the No. 777E, except without the third or fine grind section; produces drip and regular grinds only. Fine grind section can be added at any time, to convert to No. 777E model.

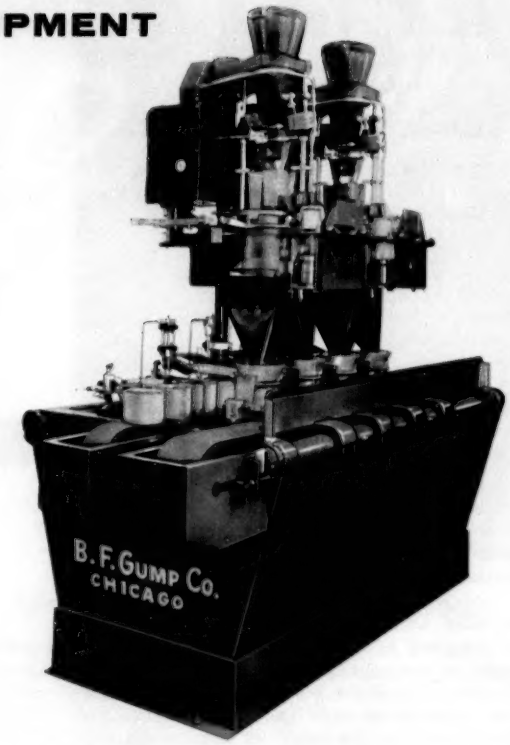


No. 888E GUMP COFFEE GRANULIZER. Produces the complete range of fine, drip and regular grinds, in capacities up to 4000 pounds per hour. With a complete range of grinds in big capacity, the No. 888E is the standard production unit in large plants. It synchronizes with packaging equipment producing 60 one-pound packages per minute.

No. 88E GUMP COFFEE GRANULIZER is the same model as the No. 888E, except without the third or fine grind section; produces drip and regular grinds only. Fine grind section can be added at any time, to convert to No. 888E model.

B. F. GUMP CO., Chicago 50, Illinois

BAR-NUN PACKAGING EQUIPMENT



Bar-Nun Packaging Equipment is designed especially for the coffee industry—to package ground and whole bean coffee with extreme accuracy, speed and dependability. Investment in this efficient packaging equipment is repaid by immediate and measurable savings. By eliminating losses due to excessive overweights substantial savings in coffee are realized over a year's time; and high speed, dependable production means more packages with minimum labor requirements.

BAR-NUN "Auto-Check" CAN LINES

automatically feed, fill, pack and eject vacuum cans or jars

Simplified design and automatic interlocking controls enable the Bar-Nun Can Line to maintain heavy production schedules with a real minimum of supervision. This assurance of packaging on schedule—plus an accuracy guarantee which exceeds even that of other Bar-Nun "Auto-Check" Weighers—offers an opportunity for new packaging economies to anyone packing in vacuum cans or jars. Bar-Nun Can Lines are manufactured in eight sizes, with up to eight weigher units in the line, to deliver up to 200 cans or jars a minute.

On one-half and one pound weights the total overall variation of the Series 100 Bar-Nun Weigher is within 1/64 ounce plus or minus of absolute zero setting, at speeds up to 20 discharges per minute per weigher unit. The weighers may be operated at higher speeds, up to a recommended maximum, with a guaranteed accuracy within 1/32 ounce plus or minus.

How the Bar-Nun Can Line Operates

If empty cans are brought by automatic means to the can feeding conveyor, an operator is required only for visual inspection of operations and of the check-weight indicators, to assure the guaranteed extreme accuracy and to determine that all parts are functioning properly. Interlocking controls automatically place the cans or jars in receiving position under the weigher discharge spouts as the filled and packed cans are ejected to a continuous belt conveyor feeding to the closing equipment.

Packing of the coffee is accomplished while the cans are stationary and held firmly under the weigher discharge spout by an enclosing funnel to prevent spillage. There is no packing while the cans are in motion. Should a spill occur because of damaged cans being fed to the weigher, the coffee falls to enclosed spill drawers.

Continuous Production

Each of the Bar-Nun "Auto-Check" Weighers in the line operates as an individual machine, and can be cleaned or serviced while the balance of the line is speeded up to maintain scheduled production. The recommended speed of 20 discharges per minute provides for this standby capacity, and also makes it possible for the operator to visually check the weights (by means of the check-weight pointer on each weigher) without stopping production.

All electrical controls for each weigher are contained in one box, which is quickly replaced in the event of electrical parts failure. All working parts are easily accessible for cleaning, adjustment or repair, to keep maintenance time to a minimum.

A Bar-Nun Can Line maintains scheduled production under plant operating conditions . . . assures extreme unit weight accuracy . . . reduces operator and maintenance requirements . . . *saves production time, labor and coffee.*

GENERAL SPECIFICATIONS—BAR-NUN "AUTO-CHECK" CAN LINE EQUIPMENT

Model	Number of Weigher Units	Maximum Speed per Minute; ±1/64 Oz. Accuracy	Maximum Speed; per Minute; ±1/32 Oz. Accuracy	Length Overall	Width Overall	Height Overall
101	1	20	25	6 ft. 0-¼ in.	3 ft. 7 in.	7 ft. 3 in.
102	2	40	50	7 ft. 8⅜ in.	3 ft. 7 in.	7 ft. 3 in.
103	3	60	75	9 ft. 5 in.	3 ft. 7 in.	7 ft. 3 in.
104	4	80	100	11 ft. 1⅜ in.	3 ft. 7 in.	7 ft. 3 in.
105	5	100	125	12 ft. 9¾ in.	3 ft. 7 in.	7 ft. 3 in.
106	6	120	150	14 ft. 6⅛ in.	3 ft. 7 in.	7 ft. 3 in.
107	7	140	175	16 ft. 2½ in.	3 ft. 7 in.	7 ft. 3 in.
108	8	160	200	17 ft. 10⅞ in.	3 ft. 7 in.	7 ft. 3 in.

B. F. GUMP CO., Chicago 50, Illinois

BAR-NUN "Auto-Check" NET WEIGHERS stop costly overweights

- **Up to 8 ounces: maximum variation, plus or minus ¼ oz.***
- **Up to 1½ pounds: maximum variation, plus or minus ½ oz.***
- **Up to 5 pounds: maximum variation, plus or minus ½ oz.***

Bar-Nun "Auto-Check" Net Weighers eliminate costly overweights, and are speedy and extremely reliable in operation. They are recommended for semi-automatic packaging where only limited volume is required. Manually operated bag or can handling equipment is available with the weighers if desired.

Hundreds of installations have proved the efficiency and economy of these fine machines. In most plants, Bar-Nun Weighers have paid for themselves within a year. through the saving in coffee overweights, alone. A unique power feed efficiently and accurately handles even the finest coffee grinds. Dangerous underweights are eliminated as well as overweights.

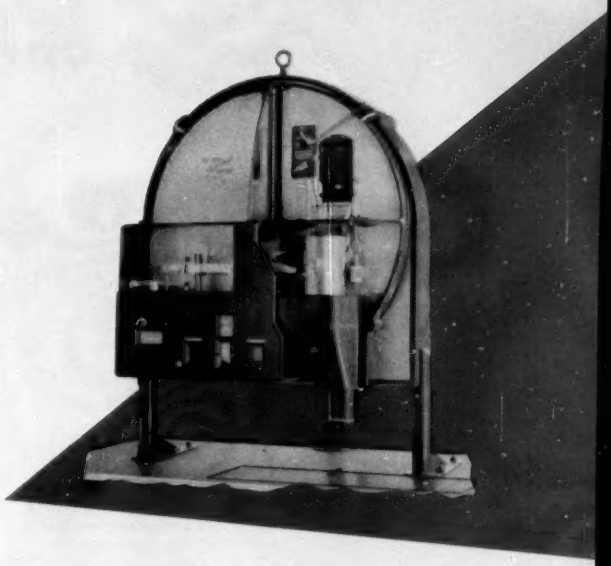
In addition, Bar-Nun accuracy and reliability effect economies through increased and steady production in the packaging department.

Operating Features

Bar-Nun Weighers are simple to install and operate. Advanced and convenient features include: *instant weight setting* on an actual scale beam, graduated in ounces and fractions thereof; *trip lever control* which reduces spillage by preventing discharge unless a container is in position under the discharge spout or the operator manually trips the control lever; *check-weight pointer and dial,* which automatically indicates the accuracy of each weight as it is made and just before it is discharged.

Bar-Nun "Auto-Check" Net Weighers are made in several models with capacities ranging from ¼ ounce to 5 pounds per discharge, as listed at right. All models can be furnished complete with the Bar-Nun Automatic Bag Feeder and Opener described below.

***Based on ground coffee.**



Model No. 20—from ¼ oz. to 8 oz. of ground coffee.

Model No. 25—from 3 oz. to 1½ lbs. of ground coffee.

Model No. 28—from 3 oz. to 1½ lbs. of ground or whole bean coffee.

Model No. 35—from 2 lbs. to 5 lbs. of ground or whole bean coffee.

BAR-NUN Automatic BAG FEEDERS, OPENERS and WEIGHERS

for almost all commonly used kraft, glassine and plastic bags, with thumb cut—with or without tin ties.

The Bar-Nun Automatic Bag Feeder, Opener and Weigher takes the bags as they come from the bag manufacturer and delivers them ready for the closing equipment. It *automatically* performs these six packaging operations:

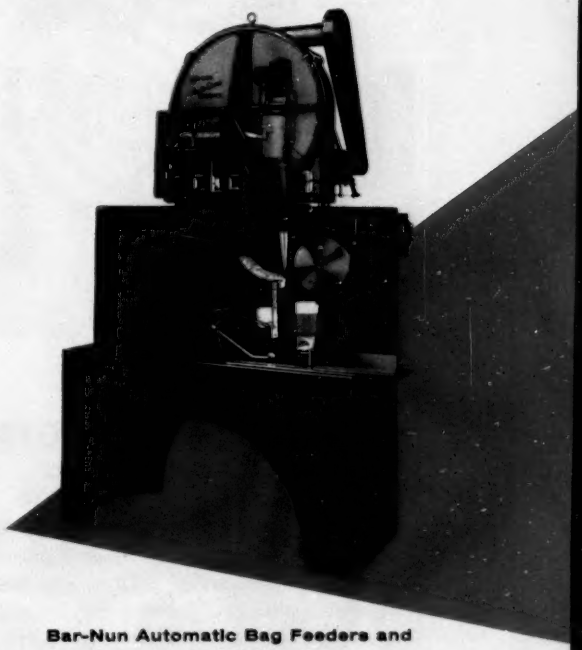
1. Feeds the paper bags, one at a time, from the magazine.
2. Opens the bag.
3. Holds it under the discharge spout of the Bar-Nun Weigher.
4. Fills the bag with an accurate weight of coffee.
5. Releases the bag. (Bag is packed as it drops.)
6. Ejects it to conveyor.

An operator is required only to keep the bag feeder supplied with bags, and to make an occasional simple adjustment. One operator at the Bar-Nun only about half time can keep it operating at capacity. With two Bar-Nuns placed side by side, one with left hand discharge and the other with right hand, one operator can easily maintain production on both machines. Operators are easily trained; no special skill is necessary.

Pay for Themselves in Savings

Operation is speedy (up to 30 one-pound packages per minute) and dependable. The usual plant experience is that labor costs are cut by one-third to one-half—plus the saving in coffee afforded by the accuracy of the Bar-Nun "Auto-Check" Net Weigher. Additional economies come from the fact that the mechanical precision of the Bar-Nun keeps production at a steady, even rate that can be efficiently scheduled with other production equipment, with resulting overall plant efficiency.

Bar-Nun users enthusiastically endorse Bar-Nun accuracy and production dependability, and say that resulting savings repay the reasonable investment in the Bar-Nun within a short time. Sturdy construction assures many years of this profitable service.



Bar-Nun Automatic Bag Feeders and Openers are available with any one of the Bar-Nun "Auto-Check" Net Weighers listed above. Different weights, within the weigher's range, can be handled on one machine by varying the heights of the bags, but bottom dimensions of all bags must be identical. Bags must have a thumb cut.

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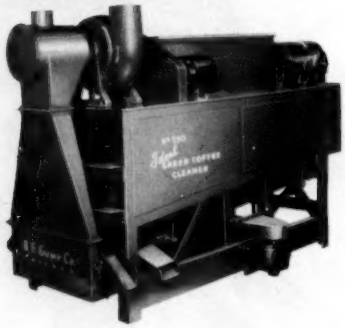
IDEAL GREEN COFFEE CLEANERS



Ideal Green Coffee Cleaners are made in two sizes: No. 550, capacity 5,000 to 7,000 pounds per hour; and No. 1100, capacity 12,000 to 16,000 pounds per hour.

Green coffee, containing hulls, twigs, strings, sticks, tags, dirt, dust, sand and many other types of foreign materials, can be thoroughly cleaned by passing it once through an Ideal Green Coffee Cleaner. The Ideal is termed the "four in one" machine, because it *feeds* the coffee at the proper capacity, then *picks out, screens out* and *sucks out* the foreign materials.

The coffee is automatically fed to revolving, indented cylinders that pick out and remove the coffee from larger particles, such as strings, sticks, tags, etc. Specially constructed flappers push the trash to waste cans. The coffee then falls onto a vibrating screen, which shakes off the small heavy dirt. The third and final cleaning is provided by the powerful aspirating system which pulls out the small light particles and dust.

Thoroughly cleaned green coffee, as produced by the Ideal, assures brighter, cleaner roasts and prevents smudge fires in the roaster or cooler.

Construction features include feed regulator, all-metal indented cleaning rolls, Juby-driven gravel and sand screen, motors and air suction system. Sturdy construction includes heavy-duty welded steel frame, ball bearings of the self-aligning type, modern chain drives and guards.

Ideal Green Coffee Cleaners are furnished complete, ready to install and operate.

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The illustration at left shows a typical Draver Continuous Coffee Blending System installation. The experience of Gump engineers assures the planning of an efficient Draver Continuous System that will effect production economies, as well as positive blend control.

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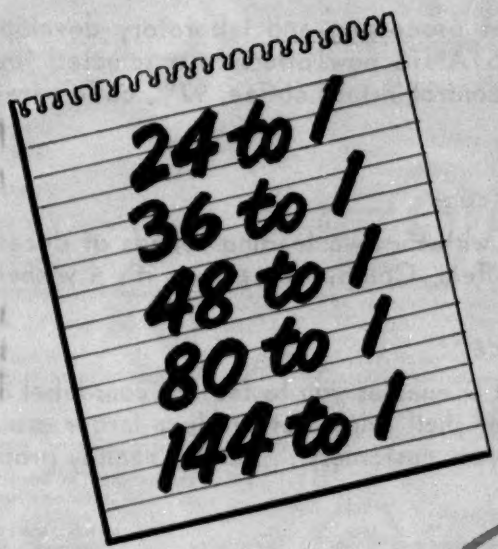

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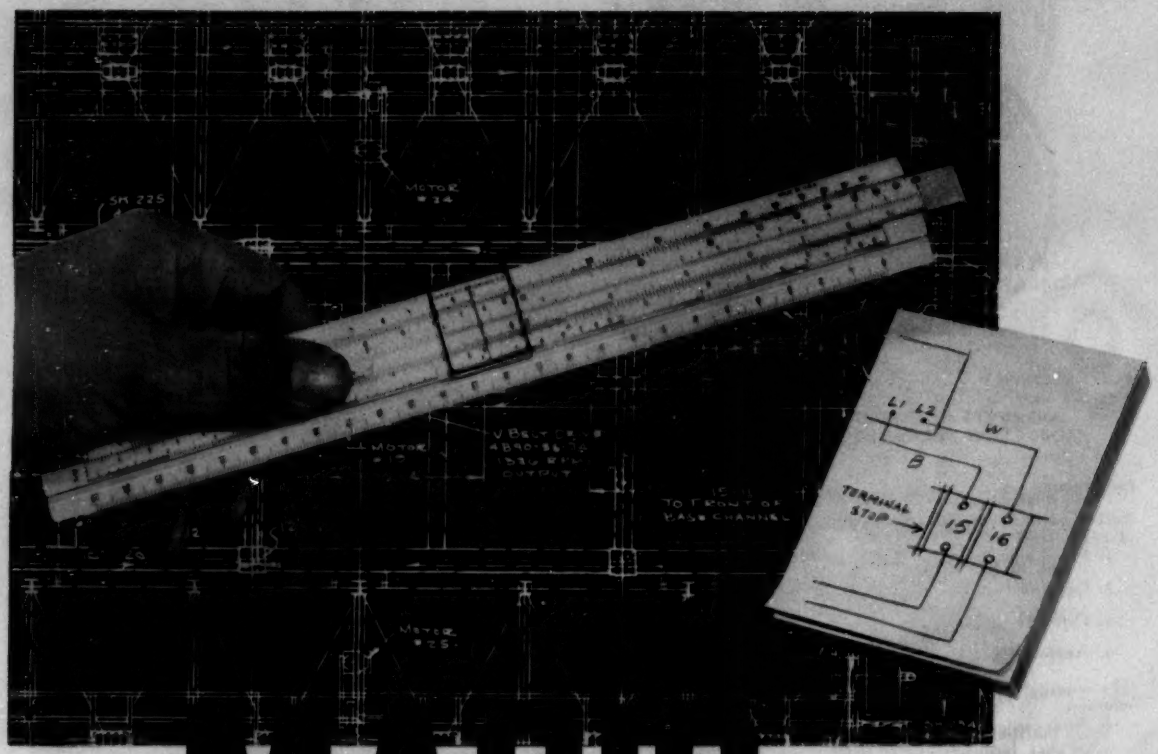

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★ **Advances in Coffee Production Technology**

Introduction

By BERNARD SACHS, Editor
Coffee & Tea Industries

This is an unusual issue of COFFEE & TEA INDUSTRIES, formerly The Spice Mill.

It contains the special section, "Advances in Coffee Production Technology," which has been in preparation for more than a year.

In the past, COFFEE & TEA INDUSTRIES has broken ground in other areas, seemingly closer to home—special issues on iced coffee, on premium merchandising, on coffee marketing perspectives.

Why this rather technical issue on coffee growing?

In a way, the answer is being given by people in all phases of coffee in many countries. Pre-publication orders for copies of this issue, based on an outline of the contents, have been unprecedented.

The material is also being reprinted in Spanish by the Inter American Institute of Agricultural Sciences, Turrialba, Costa Rica. A Portugese edition is being arranged, and one in French is under consideration.

Why this interest in "Advances in Coffee Production Technology?"

For coffee research people, the answer is clear. A world summary, such as this, was not available before. And it's needed. It's an important working tool for coffee scientists.

For coffee growers and shippers, their organizations and their governments, the answer is also clear. "Advances in Coffee Production Technology" brings between two covers data and reports affecting many immediate and long range aspects of coffee growing.

But what about the consuming countries? For example, green coffee men and roasters in the United States?

For them, the simple truth is this: "Advances in Coffee Production Technology" holds clues to the future of the product on which their business is based.

The articles *are* technical. But even the layman can get the gist of them, especially in the introduction and close of each one.

Does this research material mean even greater coffee output?

It could, in a period of coffee shortages. But today, in a situation of mounting surpluses, it's hardly likely coffee producers will apply such knowledge just to get bigger crops.

The material holds another meaning, a more basic one: more efficient production.

Part of the cost of growing coffee today is waste—insect damage, disease, low output per tree, poor quality beans, etc. As you knock out this waste, you move coffee growing economics to a base more able to yield the grower a fair return while encouraging maximum consumption.

More science in coffee growing might even help minimize, at the source, some of the peaks and valleys in output which plague the industry.

One factor, for example, which can alter coffee output is water—especially its lack. To meet this problem, work has been done on irrigation and on coffee trees resistant to drought.

Another factor is variation in quality. Even on the same plantation, quality can change markedly from season to season. A country's entire crop may differ sharply from one year to another.

Studies indicate ways of smoothing out these variations, and in the direction of consistently better beans.

In the long-term view, possibilities exist for the development of entirely new coffee beans, with desirable characteristics grown into them and undesirable ones bred out.

A continuing concern for all coffee men, especially in the Western Hemisphere, is coffee rust. In Asia, entire coffee industries were wiped out by the disease a century ago. So far, it's been kept out of the Americas, but it is an ever-present danger.

Our only assurance is in the work of the coffee scientists, as indicated in several of the articles. They have put up hemispheric barriers to the disease. They are seeking to build an arsenal to combat it if it does break out. Eventually, they might even give us coffee plantations immune to the disease.

The articles in "Advances in Coffee Production Technology" are not reports by each author on his own work. Rather, each article is a world summary on one subject, in which the author is a recognized authority.

COFFEE & TEA INDUSTRIES is grateful to the participating scientists. They took time from busy schedules, in some cases under difficult conditions, to prepare their articles.

We are especially indebted to Pierre G. Sylvain, of the Inter American Institute of Agricultural Sciences, at Turrialba, Costa Rica, co-editor of "Advances in Coffee Production Technology."

He helped nurture the basic concept for the special section. He worked out the framework for the breakdown of subject matter and the scientific people to handle the articles. As work on the issue developed, he was a source of readily available and always constructive suggestions.

This, then, is "Advances in Coffee Production Technology."

recent advances in our knowledge of coffee trees

1. PHYSIOLOGY

By PAULO de T. ALVIM, Plant Physiologist
Instituto Interamericano de Ciencias Agricolas de la O.E.A.
Zona Andina
Lima, Peru

Knowledge of the physiological principles underlying the relationship between crop yield and variation in environment and cultural practices is essential to successful crop husbandry. Obviously, it is not possible to define with certainty what is best for a crop in terms of cultural methods or ecological factors if one does not know the physiological behavior of this crop. It is generally recognized that our knowledge of the physiology of the coffee tree is limited, but there has been enough valuable research on the subject to justify summarizing and appraising the most significant findings to date.

This discussion will give special emphasis to fundamental studies on stomata behavior, photosynthesis, water relations, growth and flowering behavior, and physiological responses to light intensity. The field of nutrition is omitted because it is considered in other sections of this volume.

Fig. 1.—Opening of coffee flower buds induced by gibberellic acid. Buds on the left side of the branch painted with a 100 ppm solution; right side left as check. (A) first day; (B) sixth day; (C) tenth day. From Alvim.[5]

Stomata behavior

Because the stomata are the principal pathways through which gaseous exchanges take place between the leaf and its environment, the factors affecting their opening and closing mechanism must be properly understood whenever problems of plant-water relations and photosynthesis are discussed.

Stomata occur only in the lower epidermis of the coffee leaf. Their number varies in proportion with light intensity from 10,000 to 17,500 per cm^2, or 300,000 to 650,000 per leaf, for shade and sun leaves respectively.[25] The outside measures of a closed coffee stomata average 25 x 17 micra (length x breadth of the two *guard cells*).

As in most species, coffee stomata are usually open during the day and cosed at night. Dew deposition, however, may induce partial opening at night[6] and several studies have demonstrated that strong sunlight (above 8,000 foot-candles) usually causes partial stomatal closure on *fully exposed leaves*.[6, 12, 27] The stomata of partially shaded leaves are wide open for nearly the entire day.

Partial stomata closure under direct sunlight is sometimes interpreted as an indication that coffee is a true shade-loving species. Little attention has been given to the fact that in an adult plant relatively few leaves are continuously exposed to direct sunlight. A recent study by Maestri and Vieira[27] with shaded and unshaded coffee in Brazil have shown that, when leaves of all parts of the plant are checked for stomatal aperture, the average value for the tree as a whole was always higher in plants without shade as compared to shaded plants. These authors also reported that stomatal opening was markedly reduced during the dry season, and that this was more pronounced when the plants were shaded.

Stomata response to light is apparently associated with interconversions of *starch-sugar* in the guard cells, as promoted by the enzyme phosphorylase.[1] The equilibrium position of this starch-sugar reaction shifts towards starch in relatively low *p*H, and towards sugar when *p*H is relatively high. Light promotes photosynthesis in the guard cells,[2] which reduces CO_2 and raises the *p*H, thus increasing the sugar concentration in the guard cells. This causes water absorption, higher turgor, and therefore widening of stomatal opening. In darkness the whole process is reversed because photosynthesis does not take place and *p*H is lowered by CO_2 production by respiration.

Obviously, under a condition of moisture tension in the plant, the mechanism just described cannot take place normally because the guard cells cannot absorb water. Studies on transpiration by rapid weighings of detached coffee leaves have indicated decrease in stomatal opening with a deficit of only 20 or 30 mg of water per dm^2 of leaf surface, and complete closure with a deficit of about 80 mg/dm^2/.[4] This could perhaps explain the decrease in the stomatal aperture by influence of strong sunlight. The temperature of coffee leaves was found to raise as much as 20°C in two minutes after transferring from shade to strong sunlight, reaching values as high as 45°C when air temperature was 25°C.[4] This rise in temperature should cause a rapid increase in transpiration, which would in a few minutes cause enough moisture deficiency to reduce stomatal aperture. However,

★ Advances in Coffee Production Technology

Recent advances in our knowledge of coffee trees

1. Physiology

Nutman[37] concluded that the closure at high light intensity did not seem to be due to decrease in water content. In a recent study, Heath and Orchard[23] presented data indicating that midday closure of coffee stomata is a temperature effect operating through accumulation of carbon dioxid in the leaf.

Small and Maxwell[42] studied the relationship between *p*H and coffee stomata opening by the technique of treating strips of epidermis with a series of buffer solutions with different *p*H. They presented data indicating that coffee stomata closed when *p*H was below 5 or above 5.6, and only remained open in the range from 5.51 to 5.6. They also stated that coffee leaves have no organic buffer system for keeping the *p*H from raising above the optimum zone for opening. On that basis they postulated a theory stating that closing at high light intensity is caused by the higher photosynthetic rate, which induced the *p*H to increase above the 5.6 level. However, the experimental evidences supporting this theory do not seem convincing. The reported optimum *p*H range for opening, from 5.1 to 5.6, was not confirmed by Alvim[4] who found that coffee stomata open above *p*H 6.0 and close at any lower values, the same as *Phaseolus vulgaris, Pelargonium zonale* and *Tradescantia zebrina*.[1] Furthermore, no one has demonstrated that starch synthesis occurs below *p*H 5.0 and above 5.6 with digestion from *p*H 5.1 to 5.6. The statement of Small that there is no organic buffer system in coffee leaves does not seem in agreement with the work of Herndlhofer,[28] who reported the presence of malic and oxalic acids in this plant.

Photosynthesis

The process by which green leaves exposed to light make plant food from CO_2 and water is affected by a number of external factors, such as light intensity, temperature, water availability, CO_2 concentration in the atmosphere, and others. Because of the importance of the shade problem, coffee photosynthesis has been studied primarily in connection with variations in light intensity. Little attention has been given to the influence of temperature and water availability on photosynthesis. These other factors are certainly of great importance and should be considered along with light intensity.

Nutman,[36] in Tanganyka, studied coffee photosynthesis under field conditions by measuring the changes in CO_2 concentrations of an air stream passing through a shallow elliptical cup fastened to the under surface of the leaf. Curves of photosynthesis rates were established for a number of environments. The maxium rate found was 4.5 mg CO_2/dm^2/hour, and the average value for all daylight hours in a cloudless day was 1.4, 2.1, and 0.7 mg CO_2/dm^2/hour for heavily shaded, moderately shaded and unshaded estates, respectively.

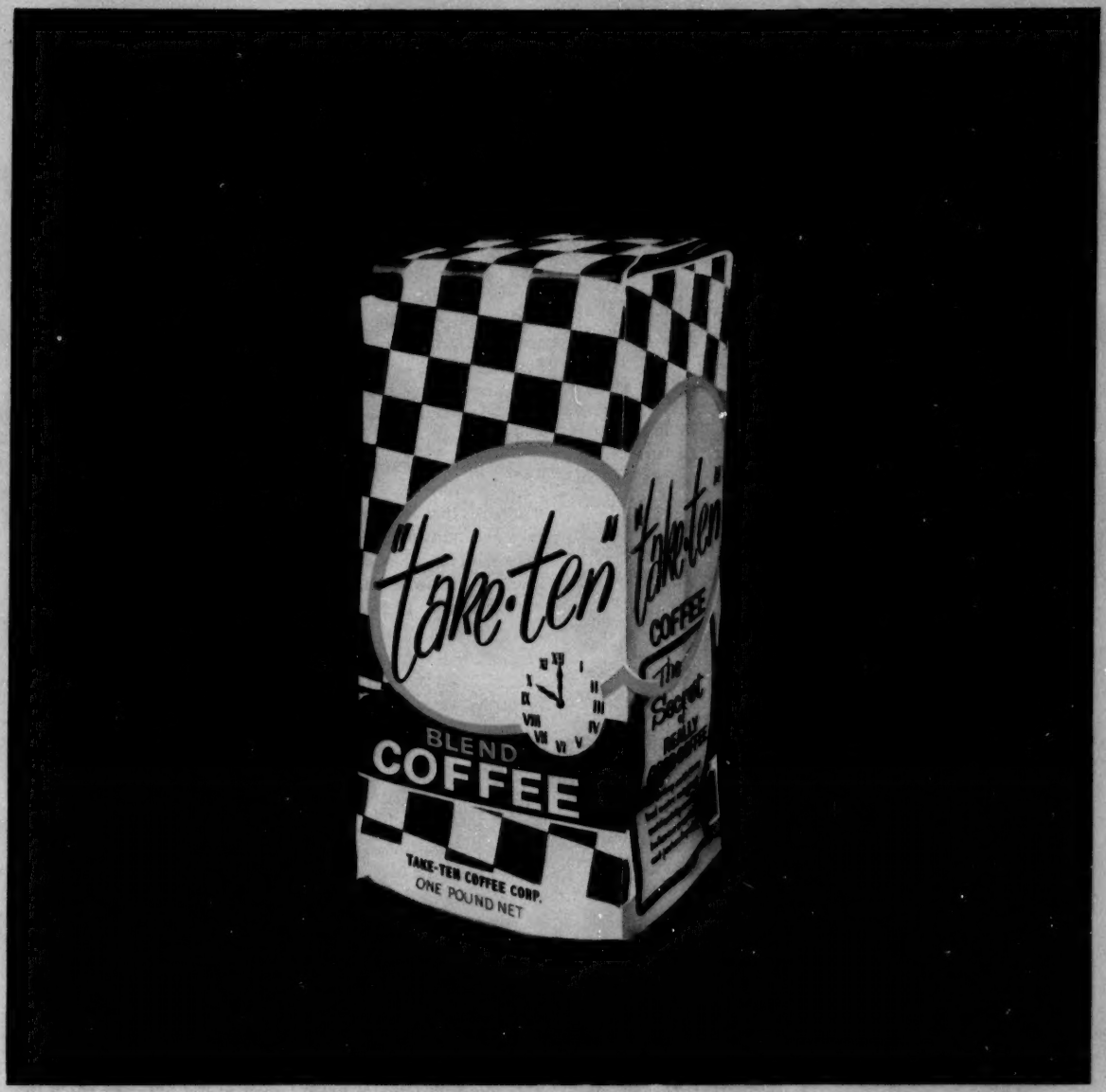
Nutman's general conclusion was that the rate of assimilation varied directly with light intensity when this was low, but light intensity reduced the rate. In cloudy weather, or under shade, the assimilation rate remains at a fairly constant and relatively high value throughout the day, whereas in the sun the rate showed large depression during midday hours. This decrease in rate of photosynthesis in full sunlight was attributed to partial stomatal closure as explained before.

As pointed out by Sylvain,[45] Nutman's results have been highly publicized but often wrongly interpreted. His conclusions are valid for individual leaves, but do not allow generalizations concerning the influence of light intensity on the photosynthetic rate of the coffee plant as a whole. Most work done on photosynthesis shows that, although in a single normally exposed leaf maximum rates are usually reached with about 25 or 30% of full sunlight, a natural mass of leaves, many of them partly to heavily shaded, generally respond to increases in illumination up to maximum light intensity. Nutman's work gives no evidence that this would not be the case in coffee as well.

Alvim[3] and Huerta[25] in Turrialba, Costa Rica, determined the influence of light intensity on the net assimilation rate (NAR) of coffee seedlings using the method lately reviewed by Watson.[49] Net assimilation rate is the increase in dry weight of the plant per unit of leaf area and per unit of time, and is usually expressed in grams/dm^2/week. Although it is not a pure measure of photosynthesis, it gives the excess of dry matter gain by photosynthesis over loss by respiration, and has more practical interest than measurement of photosynthesis alone.

On the basis of Nutman's results, Watson stated that NAR of coffee would probably decrease with increase in light intensity in the region near that of full sunlight.[49] This, however, did not prove to be the case in Alvim's and Huerta's work. Coffee seedlings were grown up to 5 months under four conditions of light intensities: 100, 60, 45 and 30%, and the values of NAR, obtained when the plants were 3-4 months old, were, respectively, 0.106, 0.083, 0.066 and 0.061 g/dm^2/week. As found with other species,[49] NAR increased lineraly with increases in the logarithm of light intensity.

The rate of photosynthesis in coffee is low compared with several other plant species, whether measured directly or expressed as NAR. Of a list of 17 plants compiled by Nutman,[36] most showed rates of photosynthesis three to six times higher than coffee and only two (*Cocos nucifera* and *Musa textile*) had lower rates. In most other plants NAR is also two or three times higher than in coffee.[22] Cacao is the only one reported to have a lower value than coffee.[20] NAR of young cacao seedlings has also been found to decrease when light intensity was above 80% of full sunlight.[4] Sylvain[45] suggests that the low rate of photosynthesis of coffee may be a limiting factor in the yielding capacity of the plant and may render it more susceptible to some physiological disturbances, like die-back; consideration should therefore be given to the possibility of producing types possessing a higher photosynthetic rate through breeding programs.



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★ Advances in Coffee Production Technology

Recent advances in our knowledge of coffee trees

1. Physiology

Water relations

Coffee is generally considered to be somewhat tolerant to drought, but yield is known to be markedly reduced when moisture supply is inadequate. Since water shortage checks vegetative growth and because coffee usually blossoms and bears fruits only on the wood that was formed by the growth of lateral branches during the previous year,[7] the decrease in yield by influence of water deficiency is seldom observed in the same year in which water shortage occurred, but in the succeeding year's crop. This was demonstrated by Dean,[10] in Hawaii, in a study on the relationship between rainfall and coffee yield. In years of limited rainfall, the plant forms fewer productive nodes for the next year's crop.

Leaf chlorosis and shedding may be very severe during prolonged dry spells. To determine the relative tolerance of coffee leaves to water shortage, Alvim[4] submitted detached leaves to wilting under 50% shade for different length of time, from 7:00 a.m. to 4:00 p.m. Every hour, moisture content was determined in a random sample of 20 leaves, and 20 others were placed in a moist chamber, wrapped in wet paper, to study recovery from wilting. The percent leaf-area killed by water shortage was estimated in the next day for each group. The first signs of killing appeared when the leaf lost 20% or 25%, of its original water content, and about 50% of the leaf-area was killed with a deficit of 55%-60%. Cacao leaves were found to be less resistant, showing first symptoms of injury with 17% deficit, and 50% killed-area with 25% deficit. Other species mentioned in the literature, such as pumpkin, sunflower, birch, alder, beech, sycamore, etc.,[28] seem far more resistant to water deficit than coffee.

The problem of assessing the water needs of coffee has been approached by studies on transpiration and evapotranspiration.

Transpiration was studied by Nutman[38] by weighing large plants in an automatic chain balance at short time-intervals. He found that transpiration, like photosynthesis, increased in proportion to light intensity when this was low, but not when it was relatively high. Partial stomata closure at higher light intensities was given as the reason for this behavior. The average transpiration rates during the day varied from 0.4 to 1.23 grams/dm²/hour. Nutman estimated that a young plant with about 1,100 leaves would lose approximately five liters of water in nine hours of illumination. A larger plant with around 400 branches and 20 leaves each could lose as much as 16 liters of water in the same period. Considering an average loss of 1 lt/hour/plant, and estimating the total root surface of the coffee tree as approximately 400-500m², Nutman figured that the rate of water absorption by the roots was around 2.5 gr/m²/hour.[35] This is considered to be a low rate of absorption in comparison with other species.

Franco and Inforzato,[18, 19] also studied transpiration by weighing potted plants, and attempted to compare the water requirements of shaded and unshaded coffee in Brazil. The highest daily rate of transpiration in unshaded coffee was 1.06 gr/dm²/hour (average for 12 hours) and the average daily value for the year was 6.29 gr/dm²/day. The total water loss per plant (abundantly watered) was estimated at about 19.9 lt. per day. On that basis an unshaded coffee field, assuming a planting distance of 3.5 x 3.5 m, would transpire an equivalent of 593 mm (23.2 in.) of rainfall per year, or approximately 50 mm (2 in.) per month.

The shade plant *Inga adulis* was found to have a transpiration rate much higher than coffee,[19] with an average loss of 19.3 liters of water per day. Previous studies have also indicated that shaded coffee receiving about 55% of full sunlight transpires 80% as much as when in 100% sunlight.[15] Thus, a shaded coffee coffee field was assumed to lose the equivalent of 476 mm (18.2 in.) of rainfall (80% of 593 mm). If *Inga* is planted in the same field at a distance of 10.5 x 10.5 m, there would be an additional water loss of 664 mm (26 in.), bringing the total loss by the shaded field to 1,120 mm (43.8 in.). Confronting the monthly water loss by shaded and unshaded coffee field with monthly rainfall in Campinas, Brazil, it was concluded that there were six months (April to September) of water deficit for the shaded field and only three (May, July and August) for the unshaded one. These findings were supported by studies of soil moisture availability[14] and indicate that water competition between shade trees and coffee plants is the main factor responsible for the failure of growing coffee under shade in most of the coffee areas of the state of Sao Paulo, Brazil. A different situation seems to exist in Ceneral America, where shaded coffee was found to have available moisture in the soil following four months without appreciable rainfall.[16] Franco suggested that Central America soils seem to have a smoother moisture-tension curve as compared to Sao Paulo soils, and transpiration rate by the plants might be slower, and consequently the available moisture remains much longer in the soil even when the field is shaded.

Evapotranspiration of unshaded coffee fields was estimated over a period of six years in Kenya, by Pereira,[39] in connection with the practical problem of assessing the irrigation requirements of this crop. His estimations were based on data from an evaporation tank, variation in soil moisture content and a series of seasonal factors. The average evapotranspiration was found to correspond to about 840 mm (32.8 in.) of rainfall. This is approximately 40% higher than Franco and Inforzato's estimation for transpiration of unshaded coffee in Brazil, but since these authors did not measure evaporation by the soil, and considering the dissimilarities between the two regions, the above difference does not seem unreasonable.

Growth behavior

The coffee plant exhibits a unique dimorphism in its vegetative growth. The apical bud develops into an upright-growing orthotropic stem with opposite-decussade

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★ Advances in Coffee Production Technology

Recent advances in our knowledge of coffee trees

1. Physiology

leaves. In the axil of each leaf there are two kinds of buds, one above the other. The lower bud, often called accessory, gives rise to new orthotropic-shoots, but usually does not develop unless the main shoot is decapitated or bent down. As postulated for other plants, *auxin* production by the terminal bud is probably what inhibits the growth of these accessory buds. Decapitation or bending down is believed to decrease the concentration of this growth hormone in the main stem, bringing it down to the level that estimulates growth of these buds.

The upper bud produces the horizontally-growing plagiotropic branches with opposite leaves. Flowers and fruits are formed in the axillary buds of these branches, but usually only in those nodes formed during the previous growing season. As a consequence, the productive nodes are continuously moving up along the branches from year to year leaving behind an increasing number of unproductive and defoliated nodes. The number of productive nodes (probably because of limited translocation of water and nutrients) tends to become progressively smaller as the shoot elongates. However, many shoots give rise to secondaries and terciaries branches, which compensates to some extent such an age effect.

Coffee differentiates from other species with dimorphic growth, such as cacao, in that its plagiotropic branches very seldom give rise to orthotropic ones. For that reason, when vegetative propagation is used in coffee, only orthotropic branches can be used, as the plant would not grow upright otherwise.

The seasonal growth cycle of coffee is governed by climatic factors, but attempts to correlate growth behavior with metheorological data have sometimes given disappointing results, chiefly in tropical regions.[6, 29, 38, 43] It is well known that growth rate is affected by water supply, temperature, light intensity, and photoperiodism, but the importance of taking into account all these factors in studies on coffee growth behavior have generally been overlooked.

1. *Water Supply:* It has already been said that a condition of water deficiency checks plant growth. In areas with prolonged dry seasons, the growth cycle of coffee is markedly affected by water supply and often follows the cycle of rains. Excess of water also reduces growth and yield because of poor soil aeration for normal root development. This seems to occur in some areas in Costa Rica, where yield was found to be negatively correlated with rainfall.[29]

2. *Temperature:* The effect of temperature has been studied by Went and his associates[50] in the climatic laboratory "Phytotron" of the California Institute of Technology. Seed germination was found to take only three weeks at 30°C, but extended for as long as three months when the temperature was kept at 17°C. Young seedlings also were found to have a fairly high temperature optimum, growing better at 30°C during night. When the first lateral branches appeared, seven or eight months after germination, the optimal temperature was lowered to 26°C day and 20° night. Approximately one year later, the optimal temperature for general development was shifted to as low as 23°C day and 17°C night, where it apparently remained for the rest of the life cycle of the coffee tree.

Went also reported that at relatively high temperatures the accessory buds of the main stem grow out spontaneously, forming a multi-stemmed plant. At lower temperatures, orthotropic branches did not develop unless the apical buds had been injured. However, in exceptional cases, there was a slight development of these buds at lower temperatures (23°C day 17° night only) and the resulting shoot might carry a few flowers and fruit, although it never elongated under these conditions.

All this work was carried out with the Bourbon variety of *Coffea arábica* L. In further experiments, also the Caturra, Mundo Novo and Semperflorens varieties were tested as to their growth responses. These varieties behaved essentially alike, except for Caturra, which showed at all temperatures a 30% decrease in growth rate.

Franco[17] reported that relatively low night temperatures (about 3°C) causes leaf chlorosis, chiefly when following days of strong sunlight. According to Drummond[11] the disorder known in Brazil as "Canela seca" (dry leg), characterized by typical girdling in the base of the trunk, appears when the night temperature drops below 3°C for at least two hours.

3. *Light Intensity* Some conflicting results have been obtained on the influence of shade on growth behavior of coffee. Studies with seedlings have shown that relative growth rate,[8, 25] plant height,[46], dry weight,[25, 44] number of lateral branches,[44] number of leaves,[25, 44] root dry weight[44] and stem diameter,[44] all seem to increase with light intensity up to full exposure. However, some authors have reported better growth of seedlings[26] and adult plants[21] under shade. Huerta[25] found that although the number of leaves increased with light intensity, the total leaf surface of the plant did not change significantly because of reduced size of individual leaves under higher illumination. The top root ratio (top dry weight/root dry weight) was found to increase also as light intensity increased.[25]

4. *Photoperiodism:* The work of Franco[13] and Piringer and Borthwick,[40] demonstrated that growth and flowering of coffee are markly affected by daylength. The total height, total number of nodes and mean internode length of the main stem apparently do not change with daylength, but short days have an inhibiting effect on growth of laterals. Under longer daylengths the laterals tend to be much longer, thus increasing the total diameter of the plant. The increased length of these branches was due to simultaneous increase in number of nodes and internode length.[40] Under short days the plant had a much narrower total diameter.

Flowering

As first suggested by Franco[13] and later confirmed by Piringer and Borthwick[40] and Went,[50] coffee is a short-day plant. Under daylength above 13 hours, or when the plant

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is illuminated at night, only vegetative growth takes place.[40] The "Semperflorens" variety is an exception, as it produces flower buds at any day-length.[50]

Mes[80] found that temperature may also affect coffee bud initiation. More flower buds were formed at a temperature combination of 23° day and 17° night than at 26/20° or 30/24°. At 30/22° many of the flower buds did not develop into normal flowers: some dried up and many formed the so-called "star-flowers" or atrophic flowers.

Went[50] reported that decreasing light intensity to slightly above 10 foot-candles at dusk and dawn is sufficient to initiate flowering of coffee plants the same as if they were subjected to additional periods of darkness. Based on these results, he suggested that shade trees may affect flowering by reducing light intensity to such values during dusk and dawn. However, as far as the author is aware, no one has ever reported differences in flowering behavior of coffee trees being associated with presence or absence of shade.

Response to photoperiodism is apparently quite pronounced in Southern Brazil (20-25° South), where bud initiation only occurs from May to July, *i.e.* when days are relatively short. In regions close to the equator, where day-length remains practically the same throughout the year, flower bud initiation apparently takes place at any period of the year.[34] However, even in equatorial regions, coffee flowering often exhibits a yearly periodicity. This periodicity seems to be associated with the mechanism of anthesis rather than with flower bud formation.

Once they are formed, coffee flower buds grow rather slowly for about two months up to a size of 6 to 8 mm and then stop growing for many weeks or even months.[30, 31, 32, 41] Rain or irrigation subsequent to a dry period are known to induce anthesis of many buds within eight to ten days. According to Porteres[41] 3 mm of rain seems to be enough to cause bud opening. Went[50] also reported that a relatively low temperature (such as 23°C day and 17°C night) may induce the buds to open in 13 days. Mes[82] postulated that it is predominantly water stress which keeps the flower buds dormant and that any treatuent which decreases the water tension inside the bud (particularly rain or submerging of buds in water) would release the inhibition. Soil irrigation is not as effective as rain.[82] In a recent study, Alvim[5] found that sprays with gibberellic acid may also induce anthesis within nine to ten days (Fig. 1). He suggested that flowering in coffee is probably controlled by a hormonal mechanism and is not directly caused by the simple physical phenomenon of water absorption. Uptake of water or a relatively low temperature could probably stimulate the synthesis or activation of a plant hormone which in turn would stimulate anthesis. This hormone could be a "gibberellin" or a chemical related to gibberellic acid.

Fruiting

Once fruit set has occurred, berries usually developed well under various growing conditions, but the rate of development seems to be strongly affected by temperature. According to Went,[50] fruit growth was very slow at 17°C day and 12°C night, where the first ripe berries were harvested nine months after transfer from higher temperatures, whereas this took only four months at the 25/20°C temperature. In nature, coffee fruits usually take about nine months to develop.

In some coffee areas, a considerable proportion of the crop is lost by abscission of growing fruits. In Costa Rica, this physiological disorder was found to be positively related to the total number of ripe fruit per branch.[33] Intensive rainfall and/or a reatively low temperature appear to be also associated with fruit drop.[33] Spraying with plant hormones does not seem to control the trouble.[33] It is suggested that fruit drop in coffee is of the same physiological nature as "June drop" of pears, citrus, etc., which seems to be caused by carbohydrate strains in the plant rather than hormone deficiency.[45]

Another physiological disorder apparently associated with carbohydrates deficiency is the formation of fruits with black seeds or "black beans."[9] In Hawaii this disorder was found to occur chiefly in those branches poorly exposed to light. Pruning has been recommended to correct it.[9]

The role of shade

Further research on physiological responses to light intensity is apparently necessary in order to conciliate the conflicting opinion concerning the role of shade in coffee growing. However, most experimental evidence now available indicates that coffee does not behave as a shade-loving species insofar as its reaction to light is concerned.[3, 25, 44, 46, 47] The author is not aware of any strong experimental evidence showing that direct sunlight *per se* is harmful to coffee. On the contrary, recent field experiments indicate that even in these regions close to the equator, such as in Colombia, where light intensity reaches values as high as 13,500 to 14,000 foot-candles during midday hours,[4] and coffee is usually grown under shade, higher yields have been obtained when the plants were grown without shade, provided the soil was fertilized and weed control intensified.[47]

It is now apparent that shade, through reducing photosynthesis as well as yield and general development of the plant, also reduces its demand for soil nutrients. This effect of shade might have been of greater importance in tropical or warmer areas of high rainfall where growth is faster and soils are generally poorer. As fertilizers were practically unknown in former years of coffee growing, shade was apparently used in warmer areas for the primary purpose of keeping the plant's demand for minerals within a limit that could be met by the soil's natural fertility, thus avoiding unbalanced nutrition or die-back of plants. Besides, shade helps to maintain soil fertility. In higher latitudes, such as in Southern Brazil and in Hawaii, there would be no apparent advantage in slowing down plant growth by the use of shade, since growth is naturally reduced during part of

the year by shorter daylength and/or lower temperature. This could probably explain why the use of shade only became a popular practice in regions closer to the equator.

Most experimental evidence now available indicates that by intensifying culture practices (fertilizers, weed control, etc.) coffee can be grown successfully without shade in any producing area. However, from the economic point of view, it is not possible to say if the increase in yield by growing without shade would everywhere be great enough to cover the additional expenses of intensifying cultural practices. This can be established through more experience and by making cost studies. In the author's opinion, shade should be considered not only as a problem related to plant physiology or agronomic practices but also to the economics of coffee production.

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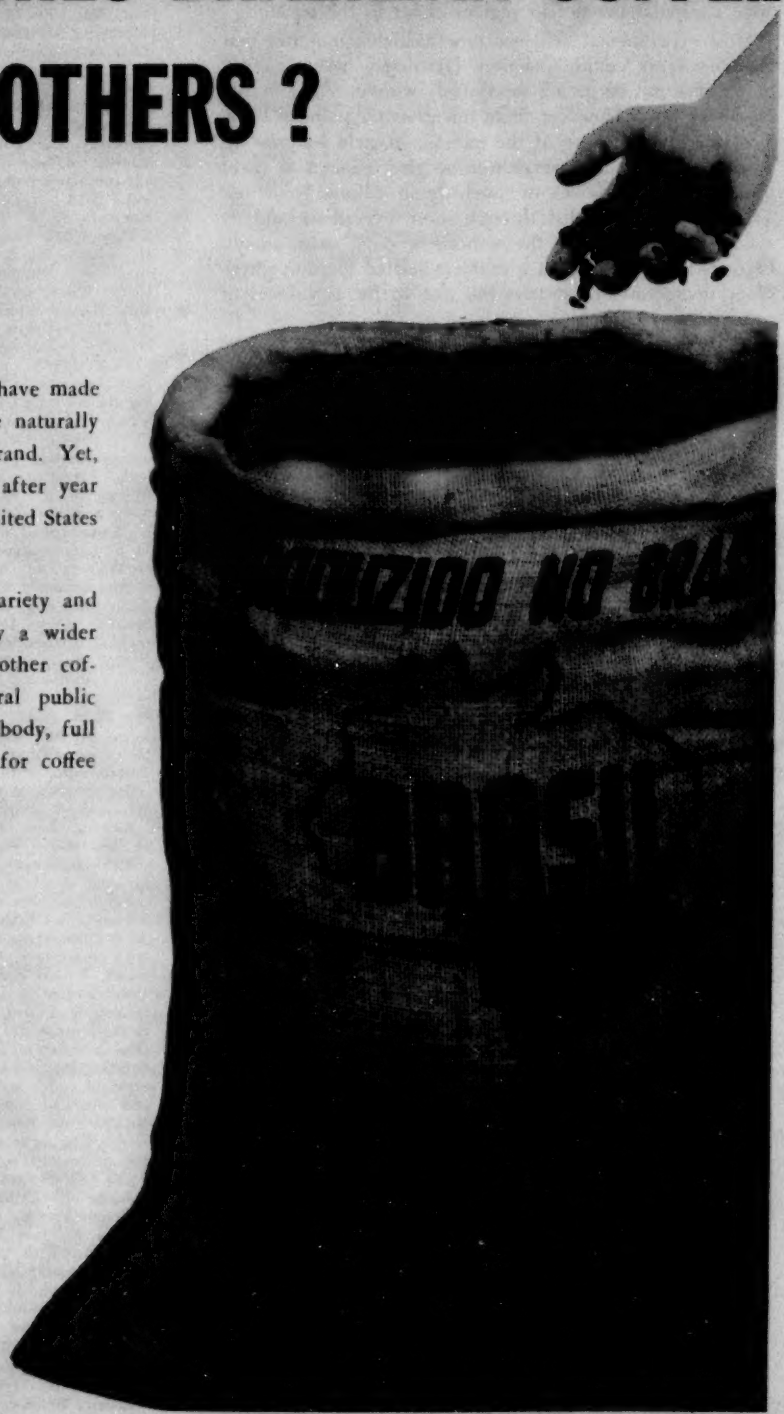

There are more than 70 species of coffee-producing trees. Of these, only two are generally used for commercial purposes, including the Arabica, the world's top quality coffee.

Above is the picture of a typical plantation in Brazil, the world's largest producer and exporter of Arabicas.

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recent advances in our knowledge of coffee trees

2. GENETICS

By ALCIDES CARVALHO, Head
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Campinas, Brazil

1. INTRODUCTION

Most of the described species of coffee are native in tropical and subtropical regions of Africa. A few wild representatives of the genus *Coffea* occur also in India, Burma, Thailand, Malay, Ceylon and Indonesia. According to recent taxonomic studies, only 60 to 70 species, belonging to the following four sections, are considered valid:

Eucoffea (24 spp.), *Mascarocoffea* (18 spp.), *Paracoffea* (13 spp.) and *Argocoffea* (11 spp.).

The *Eucoffea* section comprises the subsections: *Erythrocoffea* (4 spp.), *Pachycoffea* (5 spp.), *Nanocoffea* (5 spp.), *Melanocoffea* (3 spp.) and *Mozambicoffea* (7 spp.). To the *Erythrocoffea* subsection belong the species *Coffea arabica, C. congensis, C. canephora* and *C. eugenioides*. The subsection *Pachycoffea* comprises the species *Coffea liberica, C. Klainii, C. oyemensis, C. abeokutae* and *C. Dewevrei*.

The species *Coffea arabica, C. canephora* and *C. liberica* are the only ones cultivated at present.[2, 5, 6, 7]

In spite of the fact that coffee is one of the main agricultural products in many regions, relatively little research work exists on the variability and the genetics of even the main commercial species. It is expected that the living plant collections of representatives of the genus *Coffea* that are now being established at several coffee experimental stations will provide material for a taxonomic revision, and also for research work on the genetics and evolution of the genus *Coffea*.

Until recently, there were very few references in literature on the genetics of coffee. McClelland[11] examined the progenies of *murta* plants and concluded that this variety was of hybrid constitution. Stoffels[12] presented data concerning the heredity of the color of young leaves in *C. arabica*, without reaching a definite conclusion regarding dominance relations of the alleles involved. Ciferri[3] mentioned several already known coffee mutants without presenting any data concerning their hereditary mechanism.

At the Instituto Agronomico, Campinas, genetic investigation mainly of *Coffea arabica*, began in 1933, and the results obtained have been published in a series of papers, a general summary having been published in "Advances of Genetics."[10] Campinas is nowadays the only center where genetic analysis of coffee characteristics is being carried on. The following information is all based on data obtained at the Genetics Department of the Instituto Agronomico.

2. "TYPICA" VARIETY AS A STANDARD

The characteristics of the type plant used by Linnaeus for the description of *Coffea arabica* corresponds to that of the *typica* variety, later described by Cramer.[9] This was the first variety to be known in European botanic gardens and also the first one cultivated on the American continent. It occurs spontaneously in native Ethiopian forests. For these reasons, the *typica* variety has been chosen in Campinas as a standard in all taxonomic, anatomic and genetic investigations. The *typica* coffee can be easily maintained by selfing or by grafting. The use of a standard present several advantages, particularly for the study of dominance relations of the genetic mutants and of their interactions.[1]

3. MUTANTS OF "C. ARABICA"

Some of the heritable variations in *Coffea arabica* have, at different times, been described as botanical varieties by various authors. The genetic analysis carried out at Campinas has indicated that all these mutants differ from the *typica* variety by one to three pairs of genetic factors, being dominant or recessive to the *typica* alleles.

Coffea arabica is a relatively stable species, as so far only 30 mutants were found among hundreds of thousands of seedlings and adult plants examined in nurseries and in plantations during 25 years of work. In spite of having twice as many chromosomes ($2n=44$) as other species of the genus, all observed mutants are conditioned by single factors or by interactions between them.

3.1—Factors affecting seedling characters

Seedling characters are those which can be readily distinguished by the time the second or third pair of leaves appears. No character can be recognized only by the inspection of the cotyledon, which is always normal.

1. *na, nana.* Dwarf plants. The leaves are very small. The internodes of the main stem and of the lateral branches

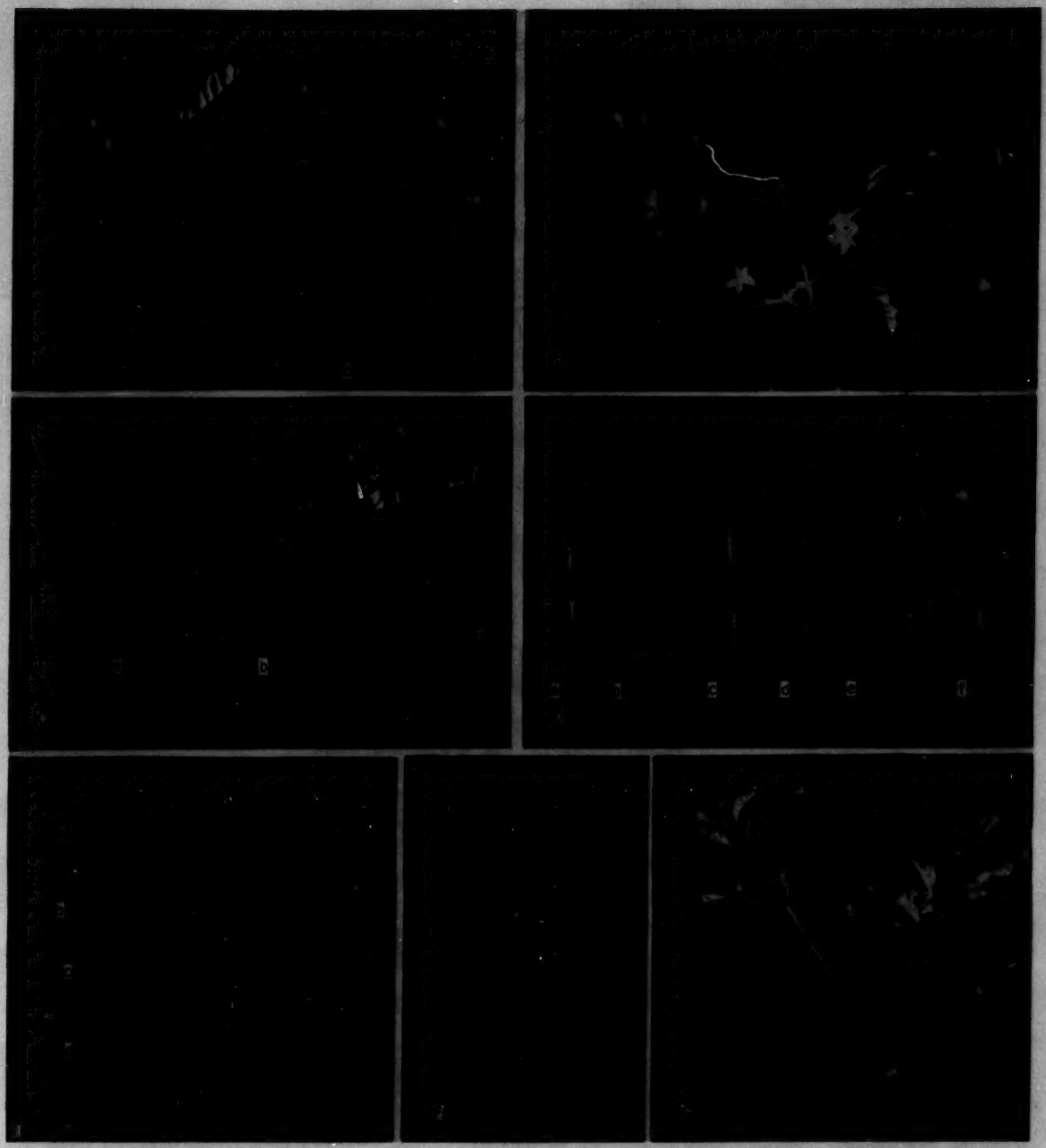

Plate 1: Mutants of "Coffea arabica." A—leaves: a, normal; b, "angustifolia" ("ag$_1$ag$_1$"); B—"semperflorens" ("sfsf"); C—branches: a, normal; b, "erecta" ("ErEr"); D—fruits: a, "typica"; b, "mokka" ("momo"); c, developed sepals ("sdsd"); d, "macrodiscus" ("mdmd"); e, "fasciata" ("FsFs"); f, "maragogipe" ("MgMg"); E—seeds: a, "typica"; b, "cera" ("cece"); c, "mokka" ("momo"); d, "laurina" ("lrlr"); e, "Maragogipe" ("MgMg"); F—flower of "calycanthema" ("Cc"); G—"anormalis" ("AmAm").

are extremely short and the plant only attains a few inches after several years. Segregation for this factor is particularly noted in the presence of the alleles *tt* (*bourbon*), plants of the genetic constitution *ttnana* being known as *nana*, the heterozygous *ttNana* as *murta*, and plants *ttNaNa* as *bourbon*. The detection of the dwarf plants is easy and can be done when the seedlings are three to six months old.

2. *ag$_1$, angustifolia.* The leaves are narrow and long. In the homozygous condition (*ag$_1$ag$_1$*), this recessive *angustifolia* factor affects plant growth and branching, resulting in multiple stems. (Plate 1, A, b).

3. *ag$_2$, angustifolia.* The leaves are narrow, long and larger than in plants *ag$_1$ag$_1$*. It is recessive. Plants *ag$_2$ag$_2$* attain normal size and the branching system is also normal. Heterozygous plants for *ag$_1$ and ag$_2$* are normal, segregating in the proportion of 9:7 in F$_2$.

4. *ag$_3$, angustifolia.* This mutant presents the leaves

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Top photo shows a view of the modern city of Abidjan, the main port of Ivory Coast. The second photo illustrates a typical coffee tree nursery in the interior. The third photo pictures the spraying of coffee trees with up-to-date equipment. On the lower left is shown a native type drying bed, although the more modern method of drying on concrete is widely used. The center picture illustrates one of the mobile hulling units in use in Ivory Coast. On the right is shown one of the new cleaning and warehousing plants in Abidjan.

characteristically narrow and long. It is recessive and not allelic to ag_1 and ag_2.

5. *Cn, crassinervia.* All the leaves are very small, thick, with prominent veins; the internodes of the main stem are very short and the plant is weak, attaining only a few inches in height, frequently dying after two to three years. Dominance is incomplete, the heterozygous individuals having a little larger and thicker leaves than the homozygous *crassinervia* seedlings.

6. *Cr, crispa.* The primary leaves are extremely small and crisp; the internodes are greatly shortened, the plant reaching a height of only 4 to 6 in. after three to four years. Dominance is incomplete, the heterozygotes being reduced in size, having very small crisp leaves. The flowers in the heterozygotes are scanty and of small size. The fruits are small, with pink exocarp, and the seeds are of reduced size.

3.2—Factors affecting plant branching

7. *Er, erecta.* The lateral fruiting branches are orthotropic. Due to this type of growth, the entire shape of the plant is modified. The dominance of the allele *Er* is complete, its expressivity is constant and the penetrance is complete. (Plate 1, C, b).

8. *po, polyorthotropica.* The main stem is abnormal with an excessively high number of orthotropic branches, resulting in an abnormal shape of the tree. This characteristic is almost completely recessive. The fruits are produced in abnormally branched inflorescences. The pedicel is long, the fruit is small, pear-shaped and provided with five stripes, which probably correspond to the sepal traces. The seeds are small.

9. ar_1, *abramulosa.* The first leaves are normal, and also the young stem. One to two years after germination the normal development of the growing point is interrupted and a strong lateral branch develops. Leaves of abnormal shape become frequent. An orthotropic bud resumes the growth of the main stem, which is again interrupted after a certain time. The growing point of the lateral branch is also paralyzed after attaining a certain size, instead two buds develop, continuing the growth of the branch. It looks as if the lateral branches had been pruned. Flowers, fruits and seeds are normal. This feature is recessive.

10. ar_2, *abramulosa.* The leaves are usually long, sometimes with two tips and frequently abnormal in shape. The young stem and the lateral branches are abnormal in development, resulting in a complex branching system. The gene is recessive.

11. *se, semi-erecta.* The young lateral branches are vertical, but the old ones become almost horizontal. The characteristic is recessive.

3.3—Factors affecting plant growth

12. *Mg, maragogipe.* The cotyledons, often more than two in number, are large. The leaves are very large, with maximum width near the base; internodes long, flowers, fruits and seeds larger than *typica.* The plant is vigorous and of great size. The allele is dominant and occurs in the commercial *Maragogipe* variety. In spite of the strong vegetative growth the yield is low. (Plate 1, D, f; E, e).

13. *Ct, caturra.* The leaves are wide, large and dark green, the internodes are short and plant size is reduced. This allele is nearly completely dominant and gave origin to the *caturra* variety (reduced size). Its yielding capacity being very high, the *caturra* variety is at present one of the preferred commercial varieties.

14. *SB, São Bernardo.* The leaves are elliptic and similar to *typica;* the internodes are short and the plant is reduced like *caturra.* Dominance is almost complete. Yield is satisfactory.

15. *SR, San Ramon.* The leaves are wide, elliptic and dark green. The internodes are extremely short and the lateral branches are of reduced length, conditioning a compact growth. Plant height is reduced. This allele is dominant and epistatic to Maragogipe in relation to plant height. It was found in the commercial variety *San Ramon.* It seems that this variety differs from *typica* by more than one main pair of factors.

3.4—Factors affecting the leaves

16. *br, verde.* The young leaves are green. This allele is almost recessive and plants *Brbr* usually present light brown young leaves. The existence of more than two alleles at this locus is suspected.

17. *pr, purpurascens.* The cotyledons are green, the young leaves are dark purple, and the mature leaves are small and of a purple green color. The interpeciolar stipules are dark purple, which sometimes facilitates the classification of the young seedling in nursery. The internodes are short and the plant height is reduced. The flowers are pink and the exocarp of the young fruit shows purple stripes which disappear when the fruits are ripe. The segregation for *purpurascens* is visible in presence of the allele *vv.*

18. *v, viridis.* The young and mature leaves are green. The *viridis* allele interacts with *pr,* giving the *purpurascens* phenotype and it does not alter the segregation in plants heterozygous for the *br* allele.

19. *Mc, mucronata.* The cotyledons are normal, but the leaves are very small, with the maximum width near the tip of the blade. The dominance is not complete. The homozygous plants are dwarf, weak and do not flower. The heterozygous are somewhat stronger, wiht larger *mucronata* leaves, and reduced height. The flowers, fruits and seeds are normal.

20. *an, anomala.* All leaves are small, narrow and irregularly shaped. The internodes are very short, and the plant presents several stems. The lateral branches are abnormally abundant. The flower shows several irregularities and the fruits usually present more than one seed per locule.

Recent advances in our knowledge of coffee trees

2. Genetics

This allele is nearly completely recessive, the heterozygous plants only seldom producing pairs of leaves with abnormal tip.

21. *Am, anormalis.* The first pairs of leaves are usually of normal shape, but the leaves produced later are extremely irregular in shape and size. The internodes are short and the branching system is abnormal. The dominance is not complete. (Plate 1, G).

22. *vf, volutifolia.* The leaves are irregularly rolled. The lobes of the corolla are also slightly rolled; the fruits and seeds are normal. It is not completely recessive.

3.5—Factors affecting flower characters

23. *sf, semperflorens.* The leaves are small and of a dark green color; the internodes are short, the lateral branches being rather short. Flowering occurs many times during the year and ripe fruits can be harvested practically every month. There are two seasons during the year when yields are higher. These characters are completely recessive. (Plate 1, B).

24. *C, calycanthema.* The flowers present a well-developed petaloid calyx; the ovary walls are of white color and the whole ovary drops with the dried corolla. The plant is therefore female sterile. Plants *CC* have not yet been found. Pollen is normal. The *calycanthema* allele is dominant; it is epistatic to the gene *sd* for developed green sepals and for the gene *md, macrodiscus.* (Plate 1, F).

25. *Fs, fasciata.* This factor has an extraordinary pleiotropic effect. Both the number of cotyledons and of primary pairs of leaves are usually not very much affected. During plant development, the number of leaves per axil rapidly increases, the fasciated stem becoming completely distorted. Fasciation also occurs in the lateral branches, though not so intensive. The number of corolla lobes and stamens is increased, the style and stigma are fasciated, the ovary is round, multilocular, the fruit is large, spherical, with abnormally shaped seeds. The factor shows incomplete dominance and conditions the characters of the variety *polysperma.* (Plate 1, D, e).

3.6—Genes affecting fruit characteristics

26. *sd, developed sepals.* Mature leaves at the end of lateral branches are sometimes distorted, small sized and variegated. The flowers have five well-developed, foliaceous and persistent sepals. The young green fruits with this developed sepals resemble the guava fruits (*Psidium guajava* L.). The gene is not completely recessive. The heterozygous plants have reduced sepals, very irregular in size and shape among the fruits of a same branch. This allele presents additive interaction with *macrodiscus.* (Plate 1, D, c).

27. *md, macrodiscus.* The leaves are small, secondary branching is abundant and the flowers have about 8-12 foliaceous, slightly developed sepals, variable in size. As the fruit grows, the fruit disc enlarges and the sepals stay on, sometimes disposed in two concentric irregular whorls. In the mature fruit, the disc is very large. The allele is not completely recessive, as the heterozygote presents a smaller disc with more than five persistent small sepals. The allele is almost hypostatic to *calycanthema* and shows interaction with "developed sepals." (Plate 1, D, d).

28. *xc, xanthocarpa.* Mature fruits with yellow exocarp. Not completely recessive, the heterozygous plants producing light red cherries. This allele seems to increase yield and the outturn by reducing the pericarp thickness. It backmutates rather frequently in somatic tissue.

3.7—Factors affecting seed characters

29. *lr, laurina.* This allele also displays an intensive pleiotropic effect. The leaves are small; the secondary branching system is very abundant, the branches having very short internodes, conditioning compact growth and a conical shape of the tree. The fruits are long, the pericarp is thick and the seeds are narrow and pointed at one end. This allele is completely recessive and conditions the *laurina* variety. (Plate 1, E, d).

30. *mo, mokka.* The leaves are elliptic and of very small size, having large and prominent domatias. The internodes are short, the flowers are of reduced size, the fruits small and round and the seeds of very small size. This allele is not completely recessive, the heterozygous plants having a rather distinct appearance and rather large domatias. In interaction with *laurina,* the *mo* allele characterizes the *mokka* variety (*lrlrmomo*). (Plate 1, D, b; E, c).

31. *ce, cera.* The endosperm is yellow instead of being greenish as in *typica.* One allele *Ce* is dominant over two doses of *ce* in the endosperm and the occurrance of xenia makes the *cera* mutant a very useful genetic tester for the determination of the amount of natural cross pollination. (Plate 1, E, b).

3.8—Chlorophyll anomalies

The irregular distribution of the chlorophyll has been observed in variegated plants. The leaves may be of the albomaculata type, being otherwise normal. This variegation is found with relatively high frequency in nurseries and also in coffee plantations. In all variegated coffee plants so far studied, this type is cytoplasmically inherited. Plants have also been observed with an irregular distribution of chlorophyll and irregular shaped leaves. The structure of the leaves is abnormal and the flowers are almost completely sterile. In one instance, a certain type of variegation has also been transmitted by the pollen.[8]

3.9—Mutants obtained by X-rays

Seeds of S_4 to S_6 of *typica* and *bourbon* obtained by successive selfing, and also seeds derived from duplicated haploid *bourbon* coffee branches have been treated with

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X-rays. It has been observed that seeds treated with more than 25,000 r start germination but the young seedlings do not grow further. Most of the obtained mutants are sterile and characterized by leaf abnormalities in regard to shape and chlorophyll distribution. The branching habit is also affected.[4]

4. OTHER SPECIES OF "COFFEA"

Knowledge on the genetic characters of the varieties of other species of *Coffea* is very limited. They are known to be self-sterile and therefore genetic analysis is particularly difficult. At Campinas only a very limited amount of information has been gathered in relation to some mutants of *Coffea canephora.*

Fasciation in *C. canephora* is due to one pair of recessive genes fs^c fs^c. As in *Coffea arabica,* the gene fs^c is highly pleiotropic, conditioning fasciation of the stem, branches and flower parts. A dwarf mutant was also studied in *C. canephora.* The seedlings develop very slowly; they flower, but produce only a few fruits. *Angustifolia* also occur in *C. canephora* and is recessive as in *C. arabica.* Types of *C. Dewevrei* and of *C. racemosa* with pink corolla have recently been found. The inheritance of this character is being studied.

SUMMARY AND CONCLUSIONS

Investigation of the genetic characters of a perennial plant such as coffee requires long periods of time and involves considerable expense. These are factors that have tended to limit the information related to the genetics of coffee.

A greater number of mutants was found in the tetraploid *C. arabica* than in the diploid *C. canephora.* The reason for this may be the fact that *C. canephora,* in spite of having a very extensive geographic distribution, is self-sterile and therefore a cross-pollinated plant. *C. arabica* is self-fertile, predominantly autogamous, is usually propagated by seed, and the chances of finding recessive mutants are greater.

Several of the mutants in *C. arabica* are recessive. Some are vigorous and of economic importance, such as *bourbon* (*it*), *xanthocarpa* (xcxc) and *semperflorens* (sfsf). There are also dominant mutants with special economic interest, such as *caturra,* while others do not offer any advantages. Another fact is that most of the genes studied have a remarkable pleiotropic effect, some of them affecting many plant characters, while others have only a specific effect.

Most of the genes studied show stability; however, the *na* factor has been found to be very unstable in somatic tissue, under certain circumstances. The *xc* allele also back mutates rather frequently to the *Xc* condition in somatic tissue.

The results of the genetic studies have been of considerable help in the coffee breeding work that is being carried on at Campinas, and some of the new gene combinations may be of economic value.

Typica variety must be used as a standard in all stations where projects on genetics of *C. arabica* are being initiated.

In spite of the fact that only a limited number of genes has been studied, the gathered data from the studies of mutants and their relation to *typica* have allowed a better understanding of the origin of several of the cultivated coffee varieties.

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recent advances in our knowledge of coffee trees

3. CYTOLOGY

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1. Number and morphology of chromosomes

The cultivated varieties of coffee belong to two main groups as to their chromosome complements: the diploid (2n=22) and the tetraploid (2n=44). *Coffea abeokutae, C. bengalensis, C. canephora, C. congensis, C. eugenioides, C. Dewevrei, C. Dybowskii, C. liberica, C. stenophylla, C. Ugandae* are diploid species; the tetraploid group is constituted by the large number of *Coffea arabica* varieties (Krug—1934, 1936, Mendes—1954). There are also some references to *C. liberica* (Heyn—1936), *C. congensis* and *C. abeokutae* (Fagerlind—1937) as having 2n=44 chromosomes.

Hexaploid (2n=66) and octoploid (2n=88) individuals occur in the progenies of normal 44-chromosome Arabica plants (Krug—1936). Colchicine treated seeds of *C. canephora* (2n=22), *C. Dewevrei* (2n=22) and *C. arabica* (2n=44) produced plants with doubled chromosome numbers (Mendes—1947). Artificial and natural pollinations also resulted in Arabica plants with 55, 66 and 88 chromosomes (Krug—1937, Mendes—1946).

Interspecific hybrids between *C. arabica* and *C. canephora* are triploid (2n=33) (Krug and Mendes—1940). Through a colchicine technique (Mendes—1947) a hexaploid (2n=66) has been induced from one of such triploids.

Di-haploids (2n=22) occur in the progenies of Arabica 44-chromosome varieties (Mendes and Bacchi—1940).

Thus, there exists in the genus *Coffea* a polyploid series including 22, 33, 55, 66 and 88 chromosomes. The basic number of this series is 11, as suggested by Homeyer (1933).

The only species in which a study has been made on chromosome morphology is *C. Dewevrei*. In this species the somatic chromosomes have been grouped into three classes as to their sizes: three pairs are 2.0 to 3.3 microns long and easily distinguished morphologically, a secondary constriction being found in the largest one; four pairs are 2.0 microns long, and the remaining four pairs are from 1.0 to 2.0 microns long (Mendes—1938).

In *Coffea arabica* the chromosomes present themselves as small rods, smaller than any of the diploid species. It is interesting, however, that the size of metaphase chromosomes varies in the same root tip, according to the position of the cell in the tissue. A pre-treatment of root tips with paradichlorobenzene before fixation shortens still more the chromosomes and makes countings easier (C.H.T. Mendes—1950c).

In somatic metaphases of a hybrid (2n=33) between *C. arabica* and *C. canephora*, some of the *canephora* chromosomes could be recognized by their larger size (Krug—1937b).

2. Chromosome number and stomata

The number of stomata in coffee leaves decreases as the number of chromosomes increases. Also, the area of the stomatal openings varies with the species and directly with the number of chromosomes. This correlation has been found by Franco (1939) who studied the polyploid series, including 22, 33, 44, 55, 66 and 88-chromosome plants. It is interesting that among the 44-chromosome Arabica varieties the author found a keen exception: the stomata number of the variety *monosperma* was not included in the calculation of the mean of tetraploids because its stomata number corresponded to diploids. Later on, it was found by Mendes and Bacchi (1940) that *monosperma* plants have only 22 somatic chromosomes: they function like haploids, and cannot be considered as a true variety.

3. Number of chromosomes, compatibility and sterility

All the diploid species of coffee are self incompatible. *Coffea arabica* L., the only widely cultivated tetraploid, is also the only self-compatible species.

As has been stated above, there are some references to the existence of tetraploid forms of *C. abeokutae, C. congensis* and *C. liberica*. If such tetraploids really exist, there are no references to the change of the "status" of compatibility in those species. In *Coffea canephora* and *C. Dewevrei*, tetraploids have been artificially obtained, but were still self-incompatible.

There are also references to the existence of diploid *C. arabica* (Homeyer—1933), but nothing is known about change of compatibility. The 22-chromosome plants that sometimes occur in the progenies of the normal 44-chromosome are highly sterile. This condition, however, is not due to a change in compatibility. Cytologically, such plants be-

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have like true haploids and their sterility results from irregularities in meiotic chromosome distribution.

Hybrids between *C. arabica* (2n=44) and diploid species (2n=22) *C. canephora, C. Dewevrei* and *C. liberica* are triploid (2n=33). Their sterility is due to the irregularities that occur during meiosis. The artificially induced doubling of chromosomes, in a *C. arabica* x *C. canephora* hybrid (2n=66) determined a change from sterility to almost complete fertility. Some sterility remains because of irregularities that still occur in meiosis and which are supposed to be due to some existing similarity among the chromosomes of *C. arabica* and *C. canephora.*

A very vigorous and highly productive 44-chromosome plant has been found in Brazil. Although being self incompatible and differing morphologically from *C. arabica.* such a plant crosses readily with that species. A cytological analysis reached the conclusion that it could be a natural hybrid between *C. arabica* and *C. Dewevrei;* of its 44 chromosomes, 22 originated from the first (its haploid complement) and 22 from the second (its diploid complement) (Krug, et al—1950, Mendes—1949).

Incompatibility and sterility constitute the least known scientific fields in the genus *Coffea* and demand urgent studies. A study was initiated in Brazil on the incompatibility of *C. canephora* and *C. Dewevrei.* Cross-compatible and cross-incompatible clones are already established, but the work has been interrupted because of lack of funds.

4. Microsporogenesis and gametogenesis

Microsporogenesis has been studied in *Coffea arabica* (Mendes—1950 and Medina—1950), *C. canephora* (C.H.T. Mendes—1950a) and in *C. Dewevrei* (Medina—1952), and has been described as an entirely normal process.

The number of chiasmata per cell and per bivalent has been counted, and the results are summarized in the accompanying table.

In the 22-chromosome species *C. Dewevrei* and *C. canephora,* a pair of chromosomes appeared attached to the nucleolus in pachytene. In the 44-chromosome species *C. arabica,* from one to four pairs of chromosomes were attached to the nucleolus.

Only slight aberrations occur in the distribution of chromosomes to the microspores; very seldom microspores with n=21 are found in *C. arabica,* but there is no evidence of their being functional. Monosomic plants (2n=43) are known (Mendes—1954) but the evidences are for their origin in the fusion of a normal 22-chromosome male nucleus with a 21-chromosome egg cell.

Studying gametogenesis in *C. arabica,* Mendes (1950) observed that the first division of the microspore nucleus occurs three to four days before opening of the flowers. The vegetative nucleus was large, round, homogeneous, staining only faintly. The reproductive nucleus was small, recticulated, stained well and was located at the periphery of the cell; it was usually surrounded by a small amount of cytoplasm in a lenticular shape. The division of the reproductive nucleus usually took place in the pollen tube. Both vegetative and reproductive nuclei were observed to occur in the extremity of pollen tube.

In cloudy days, the dehiscence of anthers starts into the closed buds, but normally shedding of pollen begins shortly after the flowers open. In *C. canephora* (C.H.T. Mendes, 1950) it has been found that pollen grains are functional at least for two days.

5. Macrosporogenesis

The ovule of *C. arabica* L. consists of a single integument and a single-layed nucellus which disappears as the ovule matures. The macrospore mother cell gives rise to four macrospores, three of which degenerate, and the chalazal one becomes functional; an embryo sac of the "normal" type develops from it. The process of macrosporogenesis has been described for *Coffea arabica* (Graner —1936, 1938, and Bacchi—1941) and *C. canephora* (C.H.T. Mendes—1950b). In *C. arabica* the embryo sac is ready for fertilization the day the flower opens; in *C. canephora* it is not complete until the day following opening of the flower.

6. Embryo and endosperm development

The process of embryo and endosperm development has been studied in *Coffea arabica* (Mendes—1941).

Following pollination, double fertilization occurs, as a

Table 1: Number of Chiasmata in Three Coffee Species as determined by Mendes—1950, C.H.T. Mendes—1950 and Medina—1952.

Species and Varieties	*2n*	*Average No. of Bivalents Showing*				*Average No. of Chiasmata Per Bivalent*	
		1 Chiasma	*2 Xta.*	*3 Xta.*	*4 Xta.*	*Diakinesis*	*Metaphase I*
C. arabica	44						
rugosa		6.6	12.3	3.0	0	1.82	1.58
semperflorens		9.6	10.0	2.1	0.2	1.67	1.69
caturra		9.2	10.8	2.0	0	1.75	1.67
C. canephora	22	7	3	1	0	1.44	1.32
C. Dewevrei	22	7.3	2.7	1	0	—	1.44

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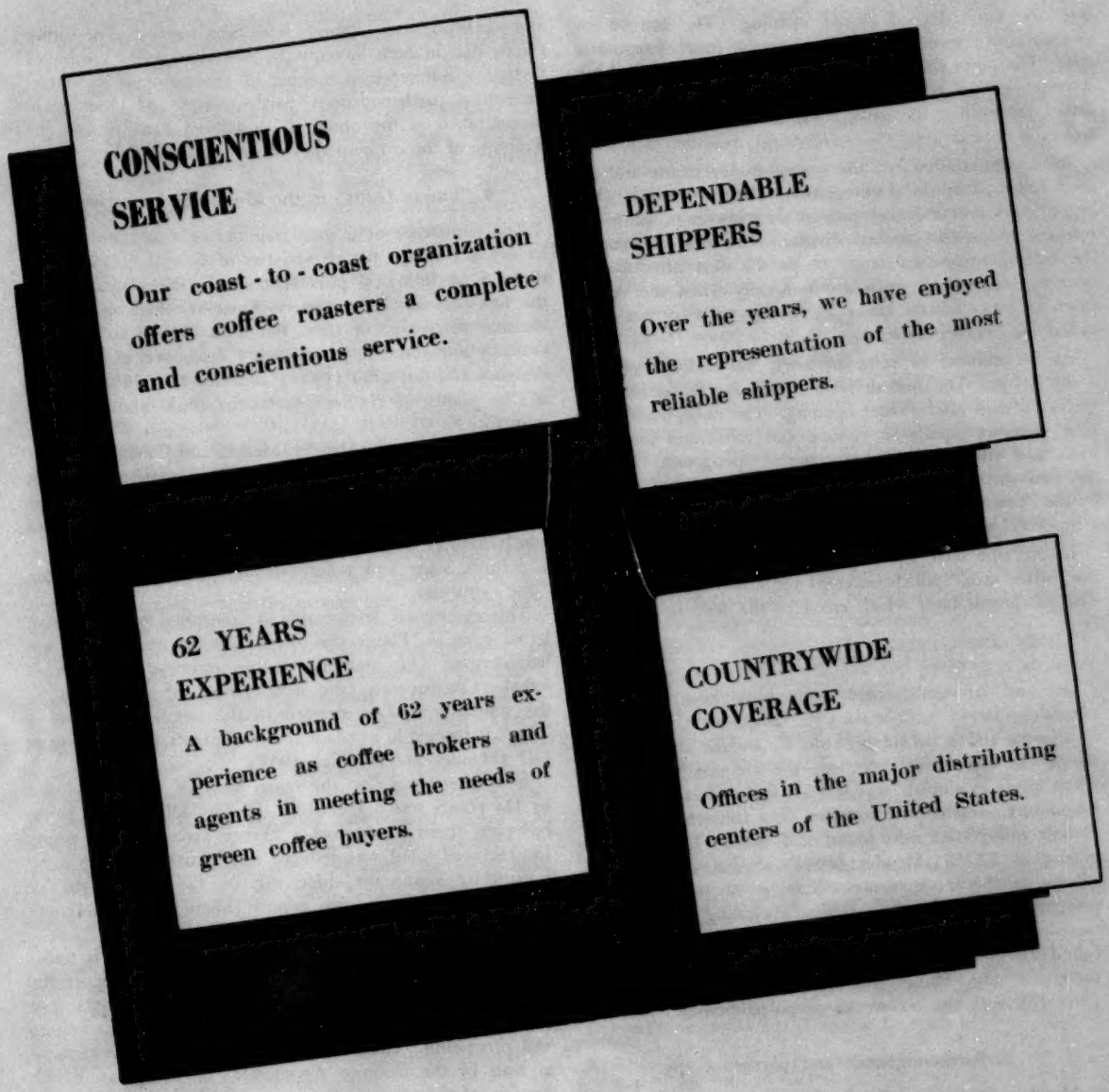
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rule, the same day of flower opening. The embryo sac increases in volume and compresses the inner integument cells. The outer cells of the integument, however, multiply actively, giving rise to a transitorial "perisperm" which grows faster than the embryo sac, attaining eventually the size of a normal seed.

Inside the embryo sac, the synergids degenerate and are soon followed by the disintegration of the antipodals. The zygote stays near the micropyle in a resting stage, while the primary endosperm nucleus divides. This first division of the endosperm occurs from 21 to 27 days after flower opening. Separating walls are seen only when the endosperm is four-nucleate; thus it belongs to what has been called the "nuclear type."

As the number of cells increases, the endosperm takes a disc shape. The first division in the zygote occurs from 60 to 70 days after flower opening. The milky endosperm now increases rapidly in volume and substitutes internally more and more the hyaline, greenish "perisperm." When the endosperm fills entirely the volume earlier occupied by the "perisperm," the embryo is well differentiated, with a hypocotyl and two small cotyledons.

In the ripe seed, the remains of the "perisperm" form the "silver skin," which envelops the now hard endosperm. The parchment layer which envelops the seed is the endocarp.

7. Polyembryony

Di- and tri- embryonate seeds have been met with (Mendes—1944) in *C. arabica, C. canephora, C. Dewevrei, C. liberica* and a hybrid between *C. arabica* and *C. canephora.* In the variety bourbon, the frequency, based on 9,453 seeds examined, was 0.8%. Embryoless seeds were found in *C. arabica* var. *bourbon,* in a frequency of 1.2%. Double embryo-sacs were found in *C. arabica* L., with a frequency of 2.27%; Mendes (1944) attributes the polyembryony to this phenomenon. Raising 72 seedlings from polyembryonic seeds of *C. arabica,* including 3 triplets, 48 twins and 21 others whose mates were not examined, he found 2n=44 chromosomes in all them and thus has not succeeded in linking the occurrence of "di-haploids" (2n=22) with the occurrence of polyembryony.

8. Parthenogenesis and parthenocarpy

Mendes (1946) attributed to parthenocarpy the occurrence of dihaploids (2n=22) in progenies of the 44-chromosome species *C. arabica;* and also the occurrence of tetraploids (2n=44) when tetraploid plants are pollinated by hexaploids (2n=66). In the cross *C. arabica* (2n=44) x *C. canephora* (2n=22), besides the expected triploids, individuals are formed with the same number of chromosomes as the seed parent. In various instances, this is also attributed to parthenogenesis. In a cross of diploid and tetraploid individuals of *C. canephora,* parthenocarpic fruits and parthenogenetic embryos have been formed. The author claims that in both interspecific and intraspecific crosses of *Coffea,* a difference in number of chromosomes sometimes determines parthenogenesis, parthenocarpy and other phenomena, such as the union of unreduced gametes and the doubling of the chromosomes of normal egg cells.

9. "Empty fruits" in the Mundo Novo variety

The occurrence of a small number of fruits with empty locules is common for all varieties of *C. arabica* and seems to be a physiological phenomenon. In the plantations of the new *Mundo Novo* variety, however, there occurred a variable percentage of trees, but high enough to be economically important, in which such a defect was exaggerated. Antunes and Carvalho (1954) admitted that 39% to 45% of the plants in regular plantations could show the abnormality.

It has been found (Mendes, Medina and Conagin—1954) that what happens in the *Mundo Novo* variety is not an increase in frequency of the above physiological phenomenon: it results from an independent and abnormal process which induces an arrest in the endosperm development at a definite stage and reduces it to an almost microscopic "disc" structure.

This cytological abnormality is controlled by a recessive lethal gene *d.* Plants that show "discoid endosperm" are heterozygous *Dd,* and the double recessive condition is lethal. Consequently, the development of endosperm in the condition *ddd* is arrested in the initial stages and a "disc" is formed in its place. Normal plants are homozygous *DD* (Mendes and Medina—1955).

It is interesting that the mean yield of fruits produced by *Dd* plants was higher than given by *DD* plants. Since, however, those plants had a higher percentage of empty locules, seed yield was reduced and actually there was no statistically significant difference in the net weight of seeds produced by the two groups (Mendes and Conagin—1955).

The presence of *Dd* trees in coffee plantations is undesirable because they have to bear more fruit to produce the same amount of seed as that yielded by the *DD* plants, thus requiring more fertilizer and increasing labor in harvesting and processing. Thus, seed now distributed to the farmers, at least by the Instituto Agronômico of Campinas, Brazil, are free of the recessive factor responsible for empty locules.

10. Monosomics

The study of mutants that occur in the progenies of different varieties of *C. arabica* has shown that frequently they are not genetic but chromosome mutations: (a) the *bullata* plants are mutants with one and half as many (2n=66) or twice as many (2n=88) chromosomes; (b) the *monosperma* plants are di-haploids (2n=22). Recently it has been found (Mendes—1955) that certain types of

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angustifolia which were of difficult genetical analysis and did not answer to the known action (Krug—1949) of *agag* genes, are monosomic (2n=43).

The *monosomics* are somewhat fertile; when selfed (Mendes—1954b) they gave rise to normal (2n=44) and monosomic (2n=43) seedlings; nullisomics (2n=42) were not found. Normal ♀ x monosomic ♂ produced only normal (2n=44) plants. Monosomic ♀ x Normal ♂ produced normal and monosomics; therefore, it seems that the male gametes lacking one chromosome were not functional.

Crossing a "cytological" angustifolia (*AgAg;* 2n=43) ♀ with a "genetical" angustifolia (*agag;* 2n=44) ♂, there were obtained plants heterozygous *Agag* and either normal (2n=44) or monosomic (2n=43). Selfing of a monosomic *Agag* produced normal and angustifolia seedlings in the ratio of 3:5. This was expected on the basis of Mendelian segregation for *Agag,* equal fertility of 21- and 22-chromosome female gametes and sterility of 21-chromosome male gametes.

11. Interspecific hybridization

It is not known if in the near future American coffee growers may be faced with diseases as terrible as the rust caused by *Hemileia,* which the present age of transport cannot restrict to non-American Areas. In the program of coffee improvement, interspecific crosses are expected to take a very important place. The introduction of desirable characteristics, such as leaf rust resistance of other species, into the high cup quality *C. arabica* is difficult because while this latter is self fertile and tetraploid (2n=44), the others are self sterile and diploid (2n=22).

Triploid (2n=33) hybrids between *C. arabica* and *C. canephora* have been obtained and studied (Krug and Mendes—1940). Many abnormalities were observed in microsporogenesis, resulting in the formation of sterile pollen grains which are extremely variable in size. Very seldom do the triploids set seed, as a result of back-crosses to *C. arabica* either through open or controlled pollination. Studying the cytological constitution of the plants obtained from these seeds, it has been found (Mendes—1951) that some triploids give rise to seedlings having mostly a chromosome number around 44, while from other hybrids this number is mostly around 55. Numerous aneuploids have been found among these progenies.

Attention has been given to the plants derived from the hybrids as to their developmental and production characteristics. At least two 44-chromosome plants have shown themselves to be interesting in these respects, and one of them, productive and self-fertile, showed up characteristics very similar to the *maragogipe* variety of *C. arabica.* The obtaining of such a plant shows that the triploids are a permanent source of new cytological combinations that can be used in the search for new, vigorous and disease resistant coffee plants with high cup quality.

12. Colchicine technique

The induction of chromosome doubling in coffee has been achieved (Mendes—1947) through the colchicine technique. Treated seeds of *C. canephora* (2n=22), *C. Dewevrei* (2n=22) and *C. arabica* (2n=44) produced plants with doubled chromosome numbers. The strength of the solutions varied from 0.15 to 0.60% and the treatment was given when the seeds were already germinating.

The author developed a new method for the treatment of sterile plants. This is the case of the triploid (2n=33) hybrids between *C. arabica* and *C. canephora* and of the di-haploid form (2n=22) of *C. arabica* known as the *monosperma* variety. Both are highly sterile, producing only a few round seeds whose embryos are of varied chromosome numbers. The method is as follows: twigs of the plants are taken to the laboratory, where they are placed into individual vials containing a solution of colchicine; after having absorbed a certain amount of the liquid, they are grafted. In the case of *Coffee,* the strength of the solution was of 0.25 and 0.50%. Through this method, 66-chromosome branches have been obtained on these grafts by treating original triploid (2n=33) tissues. Many 44-chromosome branches were also obtained from a di-haploid (2n=22) individual. In the first case, the sterility was almost entirely eliminated; in the second case, a complete change from sterility to fertility occurred.

The method is also applicable to other plants, when the treatment of seeds is not possible and grafting is an usual means of propagation.

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The New York office was opened earlier this year to foster better relations between U. S. coffee importers and packers and Guatemala.

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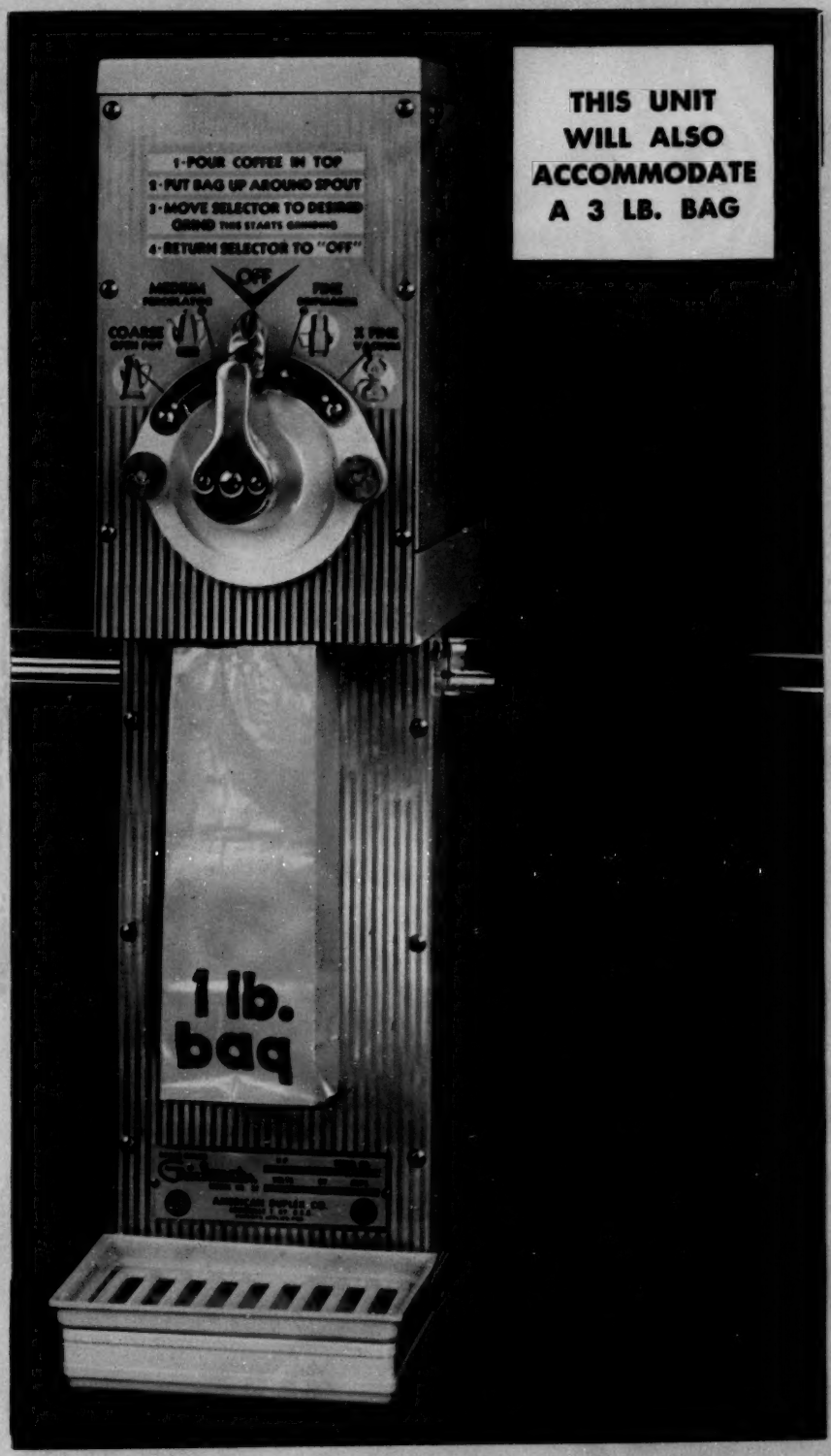

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4. ANATOMY

By D. M. DEDECCA, Head
Department of Botany
Institute Agronomico
Campinas, Brazil

The coffee-tree has been intensively studied from the anatomical viewpoint, so the following résumé, based mainly on papers by Chevalier (1947), Dedecca (1957a, b, 1958), De Wildeman (1941), etc., should be considered as a mere guide to the present knowledge on the subject.

On the other hand, since *Coffea arabica* L. is the more widely cultivated coffee species, throughout the world, the anatomical description of *C. arabica* var. *typica* Cramer has been selected as the reference for this brief discussion. Likewise, all the drawings herein presented refer to that variety.

ROOTS: The roots at the end of the primary growth present a protostelic, polyarch (5-12 primary xylem bundles), and exarch structure, the following tissues or zone of tissues being visible: *root cap, epidermis, exodermis, cortex, endodermis, pericycle, primary phloem* and *primary xylem* (Fig. 3). This primary growth has a very short duration and is very soon followed by the secondary growth, formed from a vascular cambium which makes its first appearance in a region localized approximately 5 cm from the root apex (Figs. 4 and 5).

Phellogen arises first in the pericycle and later in the phloem and gives origin to a relatively thin periderm. This protective tissue replaces the epidermis, which is gradually killed and sloughs away. Lateral roots originate from pericyclic cells situated at the protoxylem outer edges.

STEM: The origin of all stem tissues, as well as those

Plate 1. A: Root tip photomicrography, as seen in a longitudinal section (160 X). B: photomicrography of a shoot apex longitudinal section (70 X). C: photomicrography of a leaf cross section, showing a domatia (120 X).

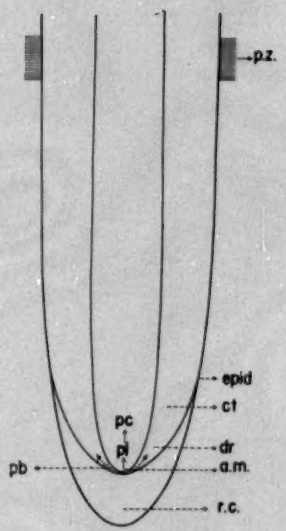

Fig. 1.—Diagramatic root tip representation in a longitudinal section (240 X).

a.m.=apical meristem
ct.=cortex
dr.=dermatogen
epid.=epidermis
pb=periblem
pl=plerome
p.z.=piliferous zone
r.c.=root cap

of the leaves, can be traced back to a dome-shaped shoot apex, which measures 220-360 microns in diameter and 48-120 microns in its major height (Fig. 6). This shoot apex, interpreted under the terms of Schmidt's theory, shows a *tunica* composed of two or three cell layers, and a *corpus* represented by a central core of irregularly arranged cells. Differentiation of meristematic tissues initiates at the distance of 800-900 microns from the shoot apex (Fig. 7), but the complete primary tissue differentiation is only achieved in a region situated 2.5 cm from the shoot apex. Stem cross sections at this level exhibit the following tissue zones: *epidermis, angular collenchyma, cortical parenchyma, pericycle, primary phloem, primary xylem* and *pith*. No distinct *endodermis* is visible (Figs. 8 and 9).

The vascular cambium, firstly visible in a region 2.5 cm from the shoot apex, originates from procambial cells localized between the xylem and the phloem, being at the beginning only fascicular; the cells of the primary rays undergo cambiform meristematic activity and interfascicular cambium is thereby formed between the vascular bundles. Following a centripetal differentiation, the cambial deriva-

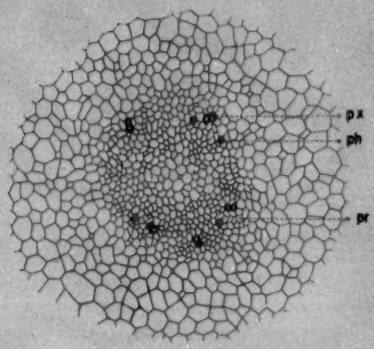

Fig. 2—Root cross section, approximately 3.5 mm from the apex, showing the pericycle (pr), and the differentiation of the protoxylem (px) and protophloem (ph) first elements. (1500 X).

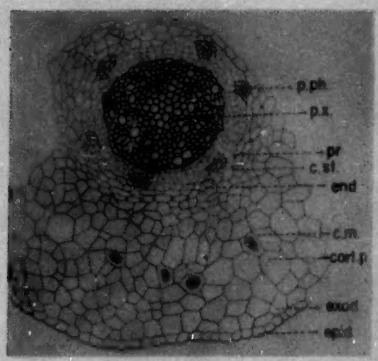

Fig.3—Root cross section showing the protostelic structure at the end of the primary growth (180 X).
cort. p.=cortical parenchyma
c.m.=crystal mass
c.st.=casparian strips
end.=endodermis
epid.=epidermis
exod.=exodermis
p.ph.=primary phloem
pr=pericycle
p.x.=primary xylem

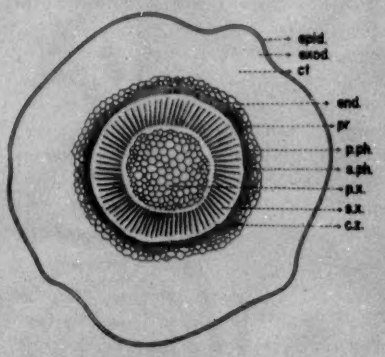

Fig. 4—Diagram showing the root histological constitution at the beginning of the secondary growth, as seen in a cross section localized approximately 5 cm from the apex (80 X).
cort.p.=cortical parenchyma
c.z.=cambial zone pr.=pericycle
end.=endodermis p.x.=primary xylem
epid.=epidermis s.ph.=secondary phloem
exod.=exodermis s.x.=secondary xylem
p.ph.=primary pholem

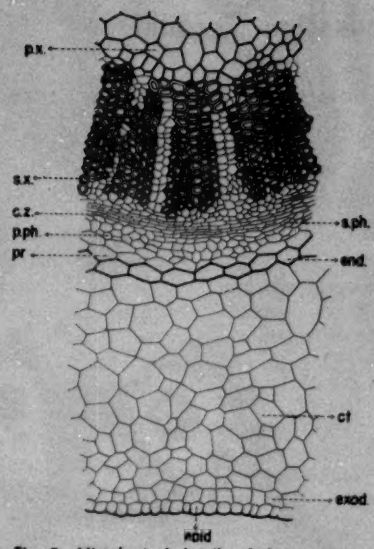

Fig. 5—Histological details of the root secondary growth, as indicated in Fig. 4 (240 X).

Fig. 6—Diagramatic representation of the shoot apex, as seen in a longitudinal section. (65 X).
g.h.=glandular hairs pc=procambium
l.pr.=leaf primordium s.a.=shoot apex

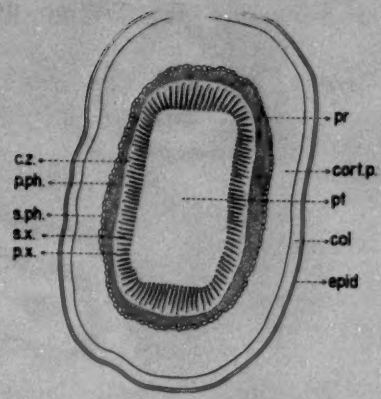

Fig. 8—Diagramatic representation of a stem cross section, illustrating the appearance of the vascular cambium and the secondary tissues derived from it (50 X).
col.=collenchyma
cort.p.=cortical parenchyma
c.z.=cambial zone
epid.=epidermis
p.ph.=primary phloem
pr.=pericycle
pt=pith
p.x.=primary xylem
s.ph.=secondary phloem
s.x.=secondary xylem

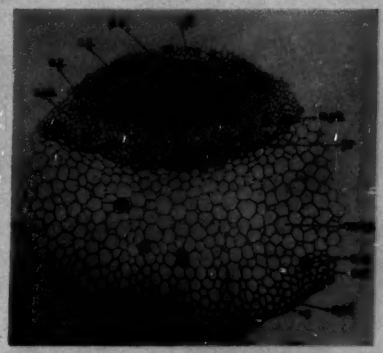

Fig. 9—Histological details of the stem, as indicated in Fig. 8 (120 X).

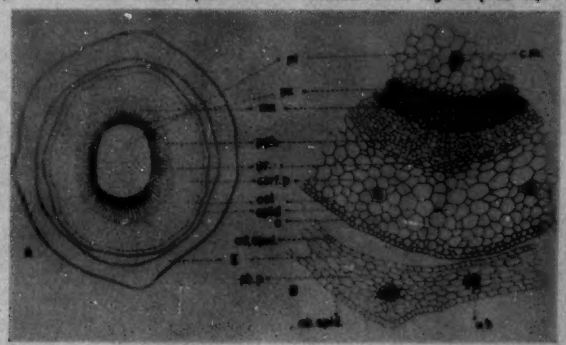

Fig. 7—Stem primary structure. A: diagramatic representation of the stem primary structure as seen in a cross section localized approximately 2 cm from the shoot apex, the stipules being also visible. (24X). B: Histological details of the same section. (42 X).
ab.epid.=stipule abaxial epidermis epid.=stem epidermis
ad.epid.=stipule adaxial epidermis mx.=metaxylem
c.=cuticle ph.p.=photosynthetic parenchyma
col.=collenchyma p.ph.=primary phloem
c.m.=crystal mass pr.=pericycle
cort.p.=cortical parenchyma pt.=pith
E=stipule px=protoxylem
v.b.=vascular bundle

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tives give rise to continuous bands of secondary xylem and secondary phloem.

Older stem cross sections present a periderm which is about 70 microns thick. Cork cambium arises from the innermost cells of cortex and produce cork externally and phelloderm internally (Fig. 10).

LEAVES: Petiole presents a tricyclic structure, exhibiting three vascular bundles, the major one corresponding to the mid-rib; all the bundles show a normal orientation of the xylem and phloem tissues. Secondary vascular bundles are also present towards the wings of the petiole cross section (Fig. 11). The phloem cylinder is generally three times less thick than the xylem one; in *Coffea arabica,* however, both cylinders are equally thick and the vascular bundles are indistinct, while in *C. canephora* and its varieties, the phloem bundles are very neatly separated from one another by large cells of the medullary rays. Tannin and calcium oxalate are commonly found in the cells of the petiole fundamental tissue.

The structure of foliage blade is that of typical leaves of dorsiventral symmetry. At an early stage, the blade consists of seven layers of relatively undifferentiated cells (Fig. 12).

At maturity, just one layer *of palisade parenchyma* and ten to twelve layers of *spongy cells* are present. Regular amounts of tannin, starch grains and granulated calcium oxalate may be found in the cells of both tissues. In most *Coffea* species, the mesophyll is homogeneous, being constituted only by parenchyma cells, but in the species belonging to the *Mascarocoffea Section,* according to Chevalier (1947), the occurrence of branched sclereids may be considered as a characteristic feature for the section.

Upper epidermis is uniseriate and formed only by epidermal cells proper; uniseriate lower epidermis exhibits these cells and stomata which are of the rubiaceous type, being formed by two guard cells and two subsidiary cells. Remarkable is the occurrence on the lower epidermis of certain structures called *domatiae* (Fig. 13); the constancy of these structures on the lower epidermis of the leaves of *Coffea* and a few other rubiaceous genera has been considered an important taxonomic characteristic for general identification. On the other hand, the domatia localization, shape, size and constitution, as well as the presence or absence of stomata on their outermost cell layer, or the presence or absence of hairs on the borders of the domatia aperture, have been shown to be important characteristics to be utilized in the differentiation of *Coffea* species and varieties. In most *C. arabica* varieties the domatiae are localized at the very angle formed by the secondary veins with the mid-rib, have a vesicular shape and open externally through an elliptical or round pore which measures 120-380 microns in diameter; the borders of the pore are nearly glabrous, a few hairs appearing only in a region distant from the borders; very few stomata are also present on the outermost cell layer of the domatia.

From the physiological viewpoint, domatiae have been regarded as the domicile or shelter of several parasites. On the other hand, Lundstroem (1887) prefers to consider the relation between domatiae and their inhabitants as being of the symbiotic type, admitting in this connection two domatia classes: *phytodomatiae,* when inhabited by plant microorganisms, such as bacteria (mycodomatiae) or fungi (ficodomatiae); and *zoodomatiae,* when the inhabitants are animals, such as mites (acarodomatiae), ants (mirmecodomatiae) etc. No evidence has ever been produced indicating that free-nitrogen fixing bacteria, similar to those found in the legume root nodule, may live in the domatiae, as has been stated by several authors. According to the existing evidence, the domatiae of most *Coffea* species are inhabited by mites.

Stipule structure is similar to that of foliage blade, but no differentiation between palisade parenchyma and spongy cells is apparent.

FLOWERS: The inflorescence is of the homotatic type, the lateral axes being very short; consequently the flowers are disposed in axilar glomerules; bracteoles are in two pairs for each flower set, being respectively lanceolate and triangular, and presenting the same structure of the stipules.

Calyx is very rudimentary; the sepals resemble the leaves anatomically, and present only a trace supply; the petals are united in a tube forming a salver-shaped corolla, presenting a single vascular trace each. Stamens are epipetalous and have also a single trace as vascular supply; the anthers are two-celled, opening lengthwise. At maturity, each anther exhibits in cross section four pollen-sacs, surrounded by an uniseriate epidermis, two fiber layers and a narrow strip of *tapetum* vestiges. Microsporogenesis is reported to be normal by several authors. Pollen grains are numerous, globose, with a very thick, smooth, and 3-4 sulcate exine.

Pistil is represented by an inferior ovary, terminal style and two stigmatic branches. Ovary is normally two-celled, each one bearing a single anatropous ovule on a central placenta; funicle is very short, and the embryo-sac is of the normal type, monosporic, 8-nucleate. Anatomically, the ovary shows to be formed by uniseriate epidermes, the outer one presenting stomata; between the epidermes there is parenchymatous tissue, and distributed in this thick parenchyma there are two or three concentric vascular bundle series.

FRUIT: The coffee fruit is a drupe, normally containing two seeds; occasionally there occurs three or more seeds, in the cases of tri-celled or pluri-celled ovaries, or through false polyembryony, when bi-celled ovaries present more than one ovule in each cell. On the other hand, by abortion of an ovule, one-seeded fruit may be formed (peaberry). Ripe fruits have a fleshy and thick pericarp. Fruit development brings about a series of chemical and morphological modifications that lead to a reduction in the thickness of pericarp, from 1.5 mm in ripe fruits to 0.4 mm in dried fruits (Fig. 14). Exocarp is represented by a single layer

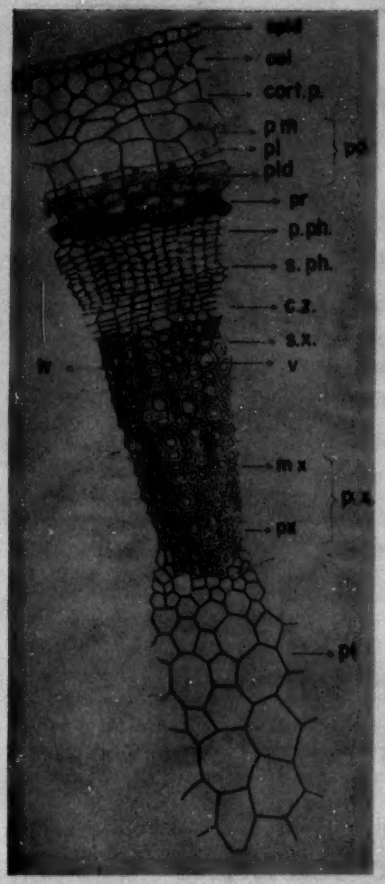

Fig 10—Stem secondary growth: Cross section made approximately 4.5 cm from the shoot apex, exhibiting a very well developed periderm (160 X).

col.=collenchyma
cort.p.=cortical parenchyma
c.z.=cambial zone
epid.=epidermis
mx=metaxylem
pd=periderm
pl=phellogen
pld=phelloderm
pm=phellem or cork
p.ph.=primary phloem
pr=pericycle
pt=pith
p.x.=primary xylem
px=protoxylem
s.ph.=secondary phloem
s.x.=secondary xylem
tr=tracheid
v=vessel element

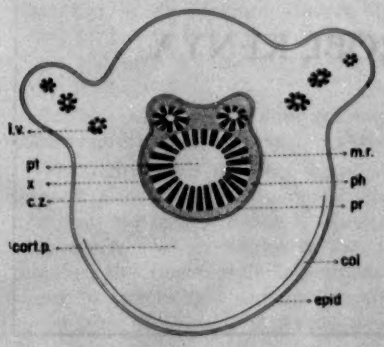

Fig. 11—Petiole diagramatic representation as seen in a cross section (80 X).

col.=collenchyma
cort.p.=cortical parenchyma
c.z.=cambial zone
epid.=epidermis
l.v.=lateral veins
m.r.=medullary rays
ph=phloem
pr=pericycle
pt=pith
x=xylem

Fig. 12—Leaf cross section (50 X).

ab.epid.=abaxial epidermis
ad.epid=adaxial epidermis
c=cuticle
col.=collenchyma
h.p.=hyaline parenchyma
ph.=phloem
p.p=palisade parenchyma
pr=pericycle
pt=pith
s.c.=spongy cells
st=stoma
x=xylem

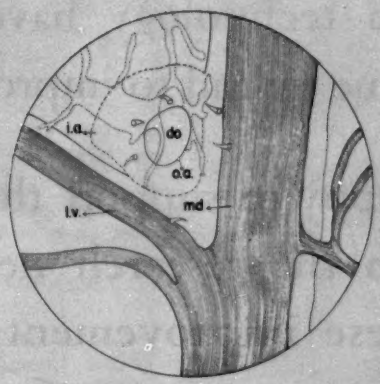

Fig. 13—Superficial view of the lower epidermis, showing a domatia (do) in the angle formed by the midrid and a lateral vein (120 X).

i.a.=inner aperture
o.a.=outer aperture
l.v.=lateral vein
md=midrid

Fig. 14—Mature fruit cross section showing the pericarp (pe) greatly reduced in thickness (32 X).

cot.=cotyledon
en.=endocarp
ex.=exocarp
m=mesocarp
s.sk.=silver skin

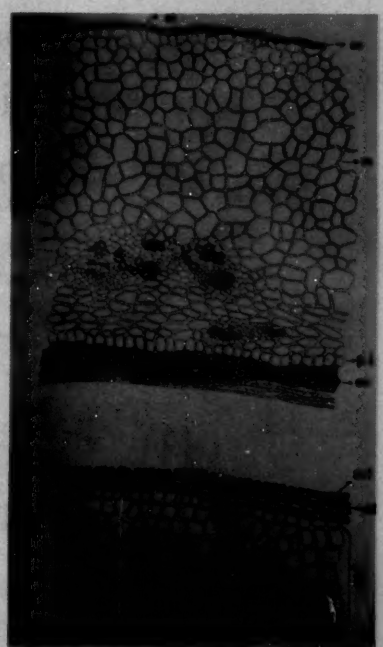

Fig. 15—Mature fruit cross section, illustrating the pericarp and seed histological constitution. (100 X).

a.t.=amorphic tissue
en.=endocarp
end.=endosperm
ex.=exocarp
m=mesocarp
pe.=pericarp
p.t.=palisade tissue
scl.=sclereids
s.sk.=silver skin
st.=stoma

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of hardened and lignified cells, with scattered stomata. Mesocarp is formed by several layers of polyhedric, large and lignified cells, the innermost of which are somewhat compressed and flattened. Amid these cells are visible the vascular bundles showing a great amount of fibers.

The portion of the fruit constituted by the innermost cell layers of the mesocarp has been considered by Menezes and Maniero (1951), as a "new palisade tissue," which presents the function of water storage, thus playing a very important role during coffee processing for marketing. This zone of tissue has been observed in the fruit of some *C. arabica* varieties (*typica, Maragogipe, angustifolia*) and in *C. canephora*, and is lacking in many other instances; so its presence or absence seems to be a valuable anatomical characteristic for the differentiation of *Coffea* species and varieties (Fig. 15).

Chevalier (1947), studying the fruit of *C. arabica*, described the occurrence of a tissue zone also localized between the mesocarp innermost cell layers and the endocarp, to which he gave the name of *gelified zone* (couche gélifiée), ascribing to it the same function of water storage. This tissue, which is constituted by 3-4 sclerenchyma cell layers, disposed in a palisade way, is undoubtedly the same one recognized by Ukers (1955), and by Winton (1939) in his studies on the coffee fruit structure. Whether this sclerenchyma palisade tissue may occur in the fruit of any coffee species is a matter to be investigated, but it is very well known that in the fruit of *C. arabica* and *C. canephora*, this tissue zone is completely absent.

Endocarp is about 100 microns thick and constitutes in the ripe fruits the so-called "seed parchment." Studied in cross section, the endocarp shows to be formed by 5-6 layers of intercrossing strong sclereids, which gives this zone of tissue an extraordinary strength. Maceration allows detailed examination of the individual sclereids, which measure, in *C. arabica*, 75-1220 microns in length by 18-62 microns in transverse diameter, these data representing measurements made in the *typica, caturra, Bourbon Vermelho* varieties and *Bourbon Amarelo* and *Mundo Novo* cultivars (Fig. 16). In general, these sclereids have a regular spindle shape, the long type being predominant, with the exception of the *Bourbon Amarelo* cultivar, where short sclereids, besides being more frequent, are irregularly fusiform and present branching in one or both ends, or are even geniculated.

In these sclereids, cell walls are very thick and provided with ramiform pits; cell lumen is almost occluded.

The coffee seeds or coffee beans are elliptical or egg-shaped, plane-convex, possessing a longitudinal furrow on the plane surface. Seed coat is represented by the so-called "silver-skin," which ontogenetically originates from the primine, the single ovule integument. This seed coat is about 70 microns thick and anatomically is constituted by an outer layer of sclereids somewhat similar to the endocarp

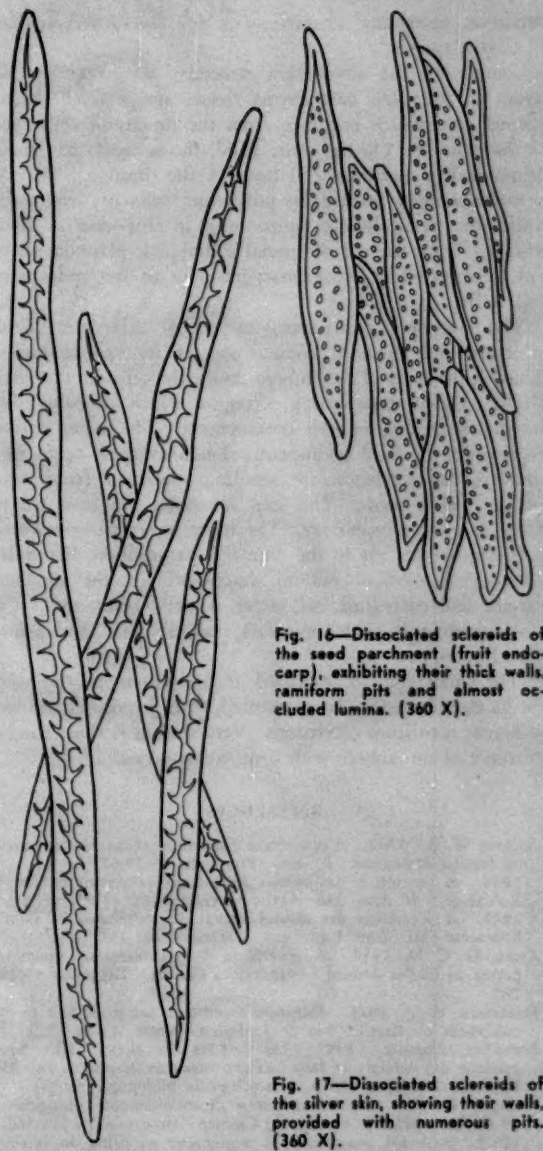

Fig. 16—Dissociated sclereids of the seed parchment (fruit endocarp), exhibiting their thick walls, ramiform pits and almost occluded lumina. (360 X).

Fig. 17—Dissociated sclereids of the silver skin, showing their walls, provided with numerous pits. (360 X).

sclereids (Fig. 17). They are, however, shorter, the longest ones measuring 120-620 microns in length and 18-36 microns in transverse diameter, according to the determinations made by Dedecca (1958) in *C. arabica* (*typica, caturra, Bourbon Vermelho* varieties and *Bourbon Amarelo* and Mundo Novo cultivars). Their thick walls are provided with round, elliptical or elongated simple pits. The size of these sclereids, and the thickness and number of pits on their walls, are considered by Chevalier (1947) as

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important taxonomic characteristics for the differentiation of *Coffea* species.

Completing the silver skin structure, there are several layers of amorphic parenchyma tissue, and a layer of indistinct cells which originate from the innermost cell layer of the primine. On the other hand, the sclereids had their origin in the outermost cell layer of the primine.

Endosperm is formed by polyhedric cells of very thick walls, the hemicellulose functioning in this case as food storage. With the aid of special techniques, plasmodesmata can be detected in the primary-pit-fields of the endosperm cell walls.

The endosperm tissue seems to present differences in the structure and chemical composition of its various layers. Thus, at the level of the embryo cavity, the cells are flattened and elongated, constituting a region which probably disintegrates during embryo development. The outer layers, represented by hard endosperm, slough away as a cap that involves the cotyledons of seedlings obtained from completely naked seeds. This cap resembles the seed parchment in gross morphology. The inner layers are considered soft endosperm. As to the chemical composition, the endosperm cells contain—besides water—protein, the alkaloids cafeine and coffearine, oil, sugar, dextrin, pentosans, cellulose, cafettannic acids, minerals, various acids and minor constituents.

The small embryo, localized at the bottom of the seed, on its convex surface is represented by an hypocotyl and two adherent cordiform cotyledons. Very seldom is there the occurrence of an embryo with 3 or 4 cotyledons.

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1. ARABICAS

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A. Introduction

Coffea arabica L., the varieties of which produce the world's high grade quality coffees, has its native home in southwest Ethiopia and, possibly, also in adjoining territories of southeastern Sudan. It is estimated that the Ethiopian "coffee forests" still cover some 400,000 hectares.

Possibly during the 13th or 14th Century, seeds of the *typica* variety were taken from Ethiopia to Arabia (Yemen) and from there by the Dutch to Java in 1690.

The Botanic Garden of Amsterdam received one single coffee seedling from that island in 1706 and furnished seed produced by this seedling to the Botanic Garden in Paris in 1713. As apparently these two Botanic Gardens were the only source of coffee seed for all coffee plantations first established in the Antilles, Central and South America, amounting to many million trees, it is believed that all that coffee, still extensively cultivated in the Western Hemisphere, actually constitutes one single progeny.

The coffee seedling introduced into Amsterdam belonged to *C. arabica* L., var. *typica* Cramer. Later, this variety was also introduced into India, Ceylon, several southeast Asiatic territories and other African regions. The great majority of these primitive plantations were established with unselected seed. . .

Arabica is still the king of coffees, contributing approximately 82% of total world production (1957/58: ± 2,500,000 tons). Its expansion has only been handicapped by the *Hemileia* rust in the Eastern Hemisphere's tropical and subtropical areas, where its production is now restricted to higher altitudes. Where this disease occurs, Arabica coffee has been replaced by its main competitor, the Robusta coffee (*C. canephora* Pierre ex Froehner), more resistant and better adapted to low and humid areas.

B. Basic research of interest to the breeder

Although much more basic information of interest to the breeder of Arabica coffee is required, a reasonable amount of data is already available to enable him to conduct his work on well established scientific grounds. Furthermore, more is known concerning *C. arabica* than about any other species of the genus.

A seed garden of Mundo Novo coffee, Campinas, São Paulo, Brazil.

The taxonomy of this species was revised by Krug and co-workers in 1939[9] and complementary information on this subject has since been published by the same authors.[1, 2] Genetic and cytological proof has been established[8, 11] that the bulk of the coffee seed is made of true endosperm. The genetics of some 30 Arabica mutants, many of economic interest, has been worked out during the last 25 years at the Instituto Agronômico of Campinas, Brazil,[7] and much is already known concerning the cytology of this species. The pollination mechanism has been worked out in detail, also with the use of genetic testers,[5, 6] indicating that Arabica varieties, under Campinas' conditions, are predominantly autogamous, over 90% of the seed being the result of natural self-pollination. Special techniques have been developed for artificial self-pollination as well as for emasculation and crossing.[5] Reasonably good information is also available on the physiology of Arabica coffee, its reaction to various environmental conditions, nutrition levels, etc. Simple vegetative multiplication techniques are available. Diseases and insect pests have been extensively studied, some of them challenging the coffee breeder in his efforts to develop tolerance or resistance. Modern experimental designs (randomized blocks, lattice, balanced incomplete blocks, etc.) have been introduced to facilitate the comparative study of a large number of progenies and strains.

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The problem of correctly evaluating cup quality is being investigated at various institutions. At the same time, detailed studies are being conducted on processing methods.

C. Varieties and cultivars

No accurate information is available regarding the extent to which each of the Arabica varieties is now under cultivation. The data mentioned below are extracted from an FAO publication, "World Coffee Survey," now being prepared by the author of this article.

With regard to nomenclature, many discrepancies still exist. The same variety often has several local names; seed received from certain regions sometimes gives rise to a coffee population which is named after the particular region of origin, such as the "Sumatra" (*typica* seed received in Brazil from that island), "Blue Mountain" (from Jamaica), and many others. Some of these "origins" may differ from the original variety by one or several minor characters or by their yielding capacity, but should by no means be classed in the range of botanical "varieties." To some of them, the name "cultivar" is more suitable. Several commercial varieties have originated from others by single gene mutations (ex: *bourbon, caturra, maragogipe,* etc.).

In India, new strains have lately come into cultivation derived from natural or artificial interspecific hybridization.

In the following chapters, some of the cultivated coffee types are tentatively classed as cultivars, in spite of the fact that the adaptation of the International Code of Nomenclature of Cultivated Plants to *Coffea arabica* L. has not yet been made.

The following are the most commonly grown coffee types of *C. arabica*:

1. var. *typica* Cramer: Having originated in southwest Ethiopia (and possibly also in southeast Sudan), this is still the most widely grown variety, particularly in the Western Hemisphere, where it is known by various names (Nacional, Comum, Criollo, arabigo, Puerto Rico, etc.). Only in Brazil and El Salvador has it been largely replaced by *bourbon* and other varieties. The *typica* is predominant in Colombia, Peru, Venezuela, Mexico (here the "Pluma de Hidalgo" cultivar is also strikingly similar to *typica*), Puerto Rico, Panama, Costa Rica and other coffee producing countries.

In Africa, it is grown to some extent in the Cameroons, Mozambique and British East Africa as the Blue Mountain cultivar; in Nigeria as "Jamaica" coffee; in Ruanda Urundi and eastern Belgian Congo (Kivu) as the "Blue Mountain" cultivar and "Local Bronze."

It has not yet been ascertained whether the "French Mission" and (or) "Mibirizi" cultivars, much grown in East Africa, derived from *typica* or from *bourbon*.

In India, the original *typica* plantations have been replaced by Kent's and Coorg's selections, possibly of hybrid (interspecific) origin.

In Indonesia, which only grows 10% Arabica the *typica* variety is represented particularly by the two local selections "Balawan Pasumah" and "Abessinia," the latter supposedly not being the *abyssinica* variety described by Chevalier.

In Hawaii, 100% of the coffee area is planted to the *typica* variety introduced from Brazil and Guatemala.

The yellow pericarp mutant (*xanthocarpa*) of the *typica* variety has little commercial value.

2. var. *bourbon* (Barb. Rodr.) Choussy: This is the second widest cultivated variety of *C. arabica,* mainly differing by one pair of genetic factors (tt) from the *typica* variety[7] to which it is far superior in yielding capacity. As Sylvain[12] first pointed out and as the author of this article could recently confirm, some coffee types in the Ethiopian forests have great similarity with *bourbon*. It is now widely grown in Brazil, particularly in the States of São Paulo (60%) and Paraná and in El Salvador (60%), its planting now also being expanded in Costa Rica (25% to 35% of the coffee areas), Colombia, Mexico, Venezuela, Puerto Rico and Ecuador. In Africa, it is primarily grown in Angola (30%). Apparently no extensive *bourbon* plantations exist in other coffee-growing areas.

The yellow pericarp *bourbon* has shown excellent yielding capacity in the State of São Paulo, Brazil.

3. var. *caturra* KMC: This is a single gene mutation of the *bourbon* variety which occurred in Brazil, where it was described[10] and later genetically analyzed. It is rather extensively grown in the Brazilian States of São Paulo, Paraná, Minas Gerais and Espirito Santo, and more recently also in Angola. This commercial mutant seems to have a very wide range of adaptability as, with few exceptions, it is doing well in many coffee areas in the world with significantly different ecological conditions. Originated in El Salvador, the "Pacas" coffee seems to be identical to *caturra,* and the "Sarchi" of Costa Rica is also a synonym of this variety.

The yellow pericarp *caturra,* originated in Brazil, has also shown excellent yieding capacity.

The "Pache" coffee is similar in growth habit to *caturra* and apparently originated as a mutation of the *typica* variety.

4. var. *maragogipe* Hort. ex Froehner: This large seeded single dominant mutant of the *typica* variety, originated in North Brazil, has been introduced into almost all coffee growing areas, but has had but little acceptance due to its low yielding capacity.

5. var. *San Ramon*: This is a semi-dwarf type which is very little cultivated in some Central American countries, as in Costa Rica. The "Villa Lobos" coffee, apparently a homozygous segregate of a cross of San Ramon with *bourbon* or *typica,* begins to be grown to some extent in the latter country.

6. The *columnaris* variety has been restricted to Puerto Rico (5%) and has no particular economic value.

7. *Mundo Novo* cultivar: This type of coffee is represented by a group of strains derived from a natural hybrid population (*bourbon* x high yielding strain of *typica*) which

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occurred in the State of São Paulo, Brazil.[4] These strains have superseded in that State and in other Brazilian regions all other Arabica varieties and strains by their extraordinary high yielding capacity.

Besides the above-mentioned coffee varieties and cultivars, there is a number of well known strains of specific local interest and, furthermore, other varieties ,such as *semperflorens, erecta, laurina, mokka, purpurascens, cera,* etc., which are of practically no commercial importance. It might just be mentioned that the author recently verified that the *cera* (yellow endosperm mutant) is grown in Yemen.

D. Methods of breeding

In a recent paper,[5] a summary has been presented on the various breeding procedures used to improve old or to breed new Arabica strains. Mass selection is still used in many countries where no facilities for more elaborate methods are available. Individual plant selection, followed by testing of their progenies, is being extensively adopted, particularly in São Paulo, Brazil, and in Kenya, Tanganyika, Belgian Congo, India, Guatemala, Colombia, Angola and El Salvador. Intervarietal and interspecific crosses have, in certain instances, given good results, and a more expanded use of these procedures is envisaged in the future. The possibility of using the principle of hybrid vigor in coffee breeding is also being investigated in Brazil.

Breedng for *Hemileia* resistance has made much progress lately in India, and the recently established Centre for Leaf Rust Investigation of the Estação Agronômica Nacional in Oeiras, Lisbon, has been able to isolate a few Arabica coffee strains which are resistant to all so far known *Hemileia* strains (Personal communication by Prof. Branquinho de Oliveira).

E. Availability of improved seed

In this section, general information is presented on the availability of improved Arabica seed in a number of coffee growing areas; also presented are additional data on the scope of the breeding work now pursued in some of them.

North, Central and South America

1. *Mexico*: Only slightly improved plant material derived from mass selection has so far been made available to the farmer. Large regional nurseries have been established by the Commission Nacional de Café during the last years, mainly of the *typica* variety, including the "Pluma de Hidalgo" cultivar. A certain amount of *bourbon* and lately also of *caturra* seedlings have been distributed free to farmers.

2. *El Salvador*: Improvement work by the pedigree method is under way, conducted by the Instituto Salvadoreño de Investigaciones de Café. The *bourbon*, and supposedly a natural hybrid, *bourbon* x *typica* (here called arabigo) are preferred by the farmers, who usually establish their own nurseries with seed from selected trees. The recently introduced *caturra* variety and its local homonym "Pacas" seem to be very promising and selected seed distribution is envisaged.

3. *Honduras*: The government has established several regional nurseries, some with mass-selected seed in each location for the production and distribution of seedlings to farmers.

4. *Costa Rica*: A coffee improvement program has been under way for several years at the Inter-American Institute for Agricultural Sciences. A large number of foreign introductions have been made and both the pedigree and the hybridization methods have been utilized. Selected seed is sold by the same Institute as well as by private farms which practise mass selection. The *typica, bourbon* and the Villa Lobos coffees are preferred, and an increasing interest for *caturra* is noticed.

5. *Colombia*: The Federacion Nacional de Cafeteros, through its Technical Department, has for several years conducted a coffee improvement program mainly concerned with the isolation of high yielding strains of the *typica* variety. Other varieties were introduced and tested in regional trials. Seed gardens of *typica* and *bourbon* selections have been established at the Federation's Regional Experiment Station for seed sale.

6. *Venezuela*: Recently some improvement work has been started, consisting of variety testing and pedigree-selection work. The government, through the "Campaña Cafetera," is developing efforts to improve the efficiency of coffee production. Regional nurseries, using mass-selected seed—*typica* and *bourbon*—have been established for the distribution of seedlings.

7. *Ecuador*: The Instituto Equatoriano de Café has now started an improvement program and has established a variety trial which includes 21 mostly imported varieties. With the most promising ones, pedigree selection work will be intensified. In order to distribute better planting material to farmers, INECAFE has started to establish nurseries planted with seed introduced from the Turrialba Institute in Costa Rica. The following varieties are recommended: "San Salvador" (probably *bourbon*), San Ramon, *bourbon* and Villa Lobos.

8. *Peru*: Seedlings sold to farmers are produced in nurseries planted with mass selected seed. Genetic improvement is being planned.

9. *Brazil*: The largest known Arabica breeding program, started 25 years ago in association with numerous basic investigations on coffee taxonomy, cytology, genetics and flower biology, is that of the Instituto Agronômico, Campinas, São Paulo, Brazil. It was initiated with the assembling of the largest possible number of coffee types existing in Brazil, and the study of their potentialities in a breeding program. Numerous new introductions were made and continue to be made, from other countries, and a constant search is underway for exceptional coffee trees, new mutants and new genetic combinations, the latter derived from natural crossings. Thousands of mother trees were selected on special breeding plots and numerous private plantations and their progenies studied in six regional experiment stations. Intra- and inter-varietal crosses, as well as numerous interspecific hybrids have been obtained and continue

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to be made, including the synthesis of (a) polyploids derived from artificial doubling of sterile triploids and (b) homozygous plants through chromosome doubling of haploids. New experimental designs were introduced for the testing of a large number of progenies. Some 60,000 to 70,000 plants are constantly under individual observation and are individually harvested each year.

The main results of this breeding project can be summarized as follows:

(a) The *typica* variety, formerly the only one grown, was completely eliminated from the project.

(b) The *bourbon* variety furnished excellent, high yielding strains, its yellow pericarp mutant having also produced outstanding progenies.

(c) Among the new varieties, the *caturra* became of special interest to farmers, due to its earliness and high yields per hectare.

(d) The most outstanding strains, however, belong to the Mundo Novo cultivar, of which it is estimated that already several hundred million trees exist in Paraná and São Paulo.

The first 62 kgs. of selected seed were distributed in 1939; they had been harvested in a plot of promising progenies. As the work progressed and the demand for selected seed increased, isolated multiplication plots of superior progenies were first established at some of the regional experiment stations, and later private farmers were urged to do the same on their farms, where seed production remained under the supervision of the Institute. At a later stage, the Extension Service also started cooperating in seed multiplication. No exact information is available on selected seed distribution, but it is estimated that during the last five years, an average of some 100,000 kgs. have been sold yearly to farmers, mainly in the States of São Paulo and Paraná, and used for replanting and establishment of new plantations (one kg. contains approximately 6,000 seeds). The latest (Carvalho), yet unpublished findings indicate that the best Mundo Novo strains produce, on an average of six regional trials (all in the State of São Paulo), 240% more than the primitive *typica* variety and 80% more than the excellent *bourbon* variety.

Antilles

1. *Puerto Rico*: A new breeding program has recently been started at the Castaner Experiment Station belonging to the University of Puerto Rico and the Mayaguez Experiment Station (USDA) is also planning to carry out some basic work of interest to the breeder. So far, no superior plant material is available to farmers, who are supplied with seedlings of recommended varieties, produced in government nurseries.

2. *Trinidad*: There is no organized distribution of selected plant material, but a selection program will soon be started.

3. *Dominican Republic*: Some experimental plantings with introduced varieties have recently been set out, but no improvement program has been started yet.

Africa

1. *Ethiopia*: In spite of the existence of a great wealth of Arabica genotypes in the native and subspontaneous coffee forests, only a very modest beginning has been made to isolate superior progenies at the Gimma Agricultural College. Two FAO experts, who have worked in Ethiopia, urged that regional nurseries be established for seedling distribution. This is now being done by the Ministry of Agriculture in cooperation with ICA experts, mass selected seed of some of the supposedly superior coffee types being used.

2. *Sudan*: Arabica growing is limited to the higher southeastern region. Besides using seed from local origin (various types), a few introductions have also been made from Ethiopia (Harrar selections), Kenya, Central America and Jamaica. Seed of some of these types is now being used to a limited extent.

4. *French Cameroons*: Large regional nurseries have lately been established by the government, mainly in the Bamiliké region for seedling distribution. Mass selected seeds of the Blue Mountain cultivar and Java (*bourbon?*) are used.

5. *Angola*: The Ganda Experiment Station, and to a minor extent the Amboin Experiment Station, both belonging to the Junta de Exportação de Café, have recently engaged in a large scale, well planned Arabica breeding project which includes: introductions; variety testing; progeny trials and hybridization. The *caturra* variety is very promising there, now covering some 50% of the area grown with Arabica. Seed multiplication plots of promising strains and varieties were established; they provided for the sale of some 5,000 kgs. of seed during the last three years.

6. *Belgian Congo*: An extensive improvement program is being conducted by the Mulungu-Tschibinda Experiment Station of INEAC, using both the pedigree method and hybridization. Promising strains of "Local Bronze" (bronze colored young leaves), "Mibirizi" and Blue Mountain cultivars have been isolated and seeds are produced on special multiplication plots. *Caturra* has so far given unfavorable results here.

7. *Ruanda Urundi*: The Rubona Experiment Station, also belonging to INEAC, is responsible for selection work. Promising progenies with bronze colored young leaves (believed to be more resistant to sun-burning) of the Mibirizi cultivar, which is grown on 95% of this territory's coffee area, have been isolated and are multiplied for distribution. The seed used in regional government nurseries for the production of seedlings to be distributed to the growers is a mixture of the best progenies.

8. *Uganda*: Seeds of Bugisu and Kent cultivars used in regional nurseries are mass selected in the best plantations available.

9. *Kenya*: The coffee improvement program of the Ruiru Experiment Station includes numerous regional variety

trials, including 114 "Miniature Trials" (single tree plots), and an extensive selection program, particularly with the

10. *Tanganyika*: An extensive breeding program has been in progress for many years at the Lyamungu Experiment Station. Numerous selections were made in the French Mission coffee, introduced from La Réunion by missionaries late in the 19th century ("N" selections), and in the Kent cultivar from India ("KP" selections). Numerous clonal and progeny trials were established, and more recently special emphasis was laid on breeding for *Hemileia* resistance. The improvement of quality is also envisaged. For many years, coffee growers have profited from seed of high yielding strains produced by this experiment station.

India

Magnificent work with *C. arabica* has been pursued by the Balehonnur Experiment Station for the last 30 years, resistance to *Hemileia* having been the main purpose. Many introductions have been made since 1926 and line selection, as well as intra- and inter-specific hybrids have been carried out there. Cytogenetic investigations have also been started. Earlier work resulted in the isolation of six desirable strains of which S.795 and S.288 are under large scale distribution all over South India. This is apparently the only coffee producing country where in some areas Robusta is again being replaced by these *Hemileia* resistant Arabica strains. Even old Robusta stumps are being grafted with these Arabica scions, the method of wedge-grafting tender suckers with scions of similar age being used.

Special seed gardens have been established by the Research Department of the Indian Coffee Board to multiply these station selections. During the period 1943/1952, some 1,300 kgs. of seed were distributed, but the demand increased considerably in the succeeding years, more than 14,000 kgs. having been sold from 1953 to 1957. Consequently, some 22% of the Arabica area is already planted with these station selections, most of the remaining 78% still being grown with the Coorg's and Kent's cultivars, selections made by private growers which replaced the primitive highly *Hemileia* susceptible *typica* strains.

Indonesia

Only about 10% of the area is grown with Arabica (estate plantations). Previous breeding work has been discontinued to a large extent, and apparently no special source of selected seed is available.

Hawaii

Genetic improvement work has only recently been started; therefore, no improved planting material is yet available. The variety successfully grown is *typica*. Its high yielding capacity seems to be mainly a consequence of good soil and plant management (large amounts of fertilizers, excellent pruning system, etc.).

Philippines

Arabica only occupies in this country a little over 7% of the total coffee acreage. Seeds or seedlings derived from selected mother trees are distributed to farmers by the Bureau of Plant Industry. More recently, an extended improvement program has been started, including the search for *Hemileia* resistance.

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F. Concluding Remarks

Reviewing the situation as to the availability of improved plant material of Arabica varieties and cultivars in the above-mentioned 25 countries and territories, one realizes that only 11 (44%) have, for a reasonable period, paid serious attention to the development of better genetic strains; that 7 (28%) have only recently started breeding projects; and that the majority, 17 (68%), still use entirely, or to a very large extent, either unselected or only mass-selected seed.

Considering that Arabica coffee is of special economic importance for some of these countries, one concludes that the expansion of breeding work constitutes a vital issue for them.

How could the Food and Agriculture Organization of the United Nations assist in this matter? By implementing the following projects which have a direct bearing on them: (1) the organization of three coffee collecting expeditions, one of them to Ethiopia, the home of *C. arabica*, and other African areas, to collect genotypes of interest to the breeding of improved varieties; (2) the establishment of a certain number of world coffee gene banks, each to be used by the breeders of groups of interested countries; (3) the establishment of regional breeding projects through international cooperation; (4) the expansion of the *Hemileia* Research Centre in Lisbon and (5) the establishment of international training centers, also for coffee breeders.

It is hoped that through the establishment of a Special Coffee Fund at FAO Headquarters, these projects can soon be implemented.

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2. CANEPHORAS (ROBUSTAS)

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1. Introduction

The wide natural variability of *Canephora* (Robusta) coffee, apparent in many characteristics, constitutes a sound base for breeding. Variability of individual yields, for instance, is demonstrated by the fact that 50% of the total crop of a tree population may be contributed by 25% of the trees, the best 10% having a performance 20 times as high as the worst 10%.[8, 41, 13]

The highly pronounced allogamous nature of the *Canephora*-group makes specific and heavy demands on the methodology.

Luckily, these aspects are somewhat moderated by the favorable circumstance that the trees are long-lived and can be easily propagated vegetatively.

When it has once been established, by means of test crosses, that a certain mother tree—or its clone—produces an excellent F_1 offspring through fertilization by pollen of one or more male partners, this F_1 can be reproduced on a large scale by planting the clone derived from that mother tree, together with the well-matched partner, as a mixture in an isolated seed plot. The desired cross-combination will then be effected spontaneously.

In breeding programs two objectives may be aimed at: (a) producing improved populations; (b) obtaining superior clones.

As to their relative importance, (b) is to be considered secondary to (a).

The actual breeding work aiming at the development of improved seedling families has been carried on more or less thoroughly in all countries where Robusta coffee is grown, i. e. Indonesia, India, the Belgian Congo, French Equatorial Africa and the British Protectorate Uganda. Details of this work can be found in section 2 of this article.

Investigations on floral biology, pollen dispersal, fruit setting, structure of male and female gametophyte, cytology, embryogeny, and the origin of seed anomalies have cleared many obstacles for the breeders. Details of this research work, mainly carried out by Dutch, Brazilian, Belgian and French scientists must be omitted here for lack of space.

2. The breeding of improved seedling strains

A. General

In all countries the breeding work was conducted along the same general lines:

(1) Selecting mother trees.
(2) Testing their generative and/or vegetative progeny.
(3) Combining the good parents to new varieties.
(4) Laying out orchards for large-scale seed-production of the improved varieties.
(5) Testing for local adaptation.

Choice and evaluation of mother trees

Considering the marked tendency to biennial or triennial bearing, there is unanimity about the fact that a mother tree, a seedling strain or a clone should be observed at least some five years to obtain a good idea about its yielding capacity. This is indeed an important standard, but not the only one. Production-rhythm, early or late maturity, distribution of yields during the cropping season, outturn, shape and size of beans, resistance to diseases and pests and tolerance to adverse external conditions also are important criteria.

In regions where the dry climate tends to reduce the size of the bean, a selection for large-beaned types is very important, as has been convincingly demonstrated by the Besuki Research Station in Eastern Java.[37] In a further stage of the breeding work, attention will also have to be paid to liquoring qualities of the bean.

There is already an increasing tendency to make a choice among the prospective mother trees after a comparatively short period of observation and to multiply the provisionally selected individuals vegetatively.

This has a twofold aim: First, it is a safety measure. If the mother tree is lost (disease, storm, lightning), the clone is still there. Second, there is an opportunity to study the rejuvenated replica of the mother trees under external conditions similar for all of them, which would

be impossible in the case of mother trees scattered over a large number of plantations.

Methods of progeny-testing and the building up of new varieties vary in different countries; these phases of the work can be better treated regionally.

B. Breeding programs in various countries

Indonesia

Coffee breeding in the former Dutch East Indies has been carried out by three institutions situated in Eastern Java: the Middle and East Java Research Station at Malang, the Besuki Research Station at Djember, and the Government Experiment Station at Bangelan.

The first systematic breeding experiments with *Canephora* date back to 1908, and the methodology has passed through all stages, from family selection to the more perfected methods of recent times.[13] Breeders could draw from a very diversified source of initial material, obtained by repeated introductions from the centers of origin in Africa. For assessing the breeding value of mother trees ,two ways have been followed:

(1) Using illegitimate (open-pollinated) seed either taken from the mother tree itself, of from its clone.

(2) Starting from legitimate seed obtained by artificial crossing.

Progeny testing was done in comparative trials, mostly replicated, and with one or more well established strains included as checks. Especially the trials of the material mentioned in (1) display a great variability among, as well as within, strains. When sufficient numbers of progenies are tested, a few will show themselves to be outstanding. Assuming that the illegitimate progeny of mother tree 187 proves to be excellent, then seed of approximately the same intrinsic value may be obtained from clone 187 standing in a seedplot surrounded by other good clones.

After the pronounced allogamous character of the *Canephora*-group had been recognized and its consequences realized, the conclusion was soon drawn that crosses between good mother trees (or clones derived from them) presented much better chances for finding outstanding combinations, which could be recreated easily with the aid of biclonal or multiclonal seed gardens.

A further advantage of this method is that a purposeful line can be taken for combining desired properties, a greater uniformity in bean size and maturity, for instance, while yet so much genetical variability remains that one need not worry about the adaptability of the new varieties. This principle was adopted around 1930, and the procedure can be presented diagrammatically as in Figure 1.

The method has one disadvantage: the number of combinations to be tried is very large. At the beginning one may, guided by breeders intuition, restrict oneself to a limited number of combinations that seem attractive. This procedure can lead and, in fact, has led to remarkable results. But in a further stage, there is no refraining from more systematic work. It has been proposed[14] to adopt the methods used in producing hybrid maize varieties and to proceed in steps. First, the mother trees are tested for general combining ability, either by means of a top-cross or simply by testing their illegitimate progenies. Only the restricted number of individuals that possess a good general combining ability can be considered for systematic

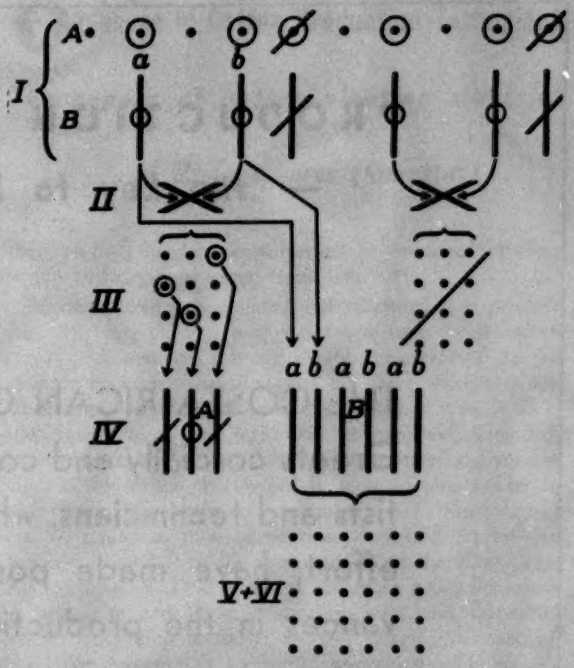

Figure 1. Schematic representation of coffee breeding procedure in Java. I. A.: Initial material (population) from which mother trees are selected (O) and others rejected (/). B: Progeny rows of clones derived from initial material (O = selected, / = rejected).

II. Intercrossing mother trees in as many combinations as possible.

III. Testing of F_1 progenies and selection of new mother trees (O).

IV. A: Testing of second cycle clones. B: Seed of the superior cross A X B is increased by means of biclonal seed gardens. V + VI. Assessing local suitability and establishing commercial plantations of seedlings A X B.

diallel crossing in order to ascertain the specific combining ability.

At the outbreak of World War II, hundreds of pair crosses of the type just discussed stood in the trial gardens of the above-mentioned three institutions, in order to be tested. Much of the material and the data collected from it was lost during the war and in the turbulent postwar period, but what it has been possible to reconstruct and summarize has yielded much valuable information.[17, 20]

Seedplots

When it has been proved that clone A and B combine well, seed of the composition A x B is raised in quantity by putting clone A and B together in a seed plot. Proper care should be taken to exclude unwanted pollen, either by laying the seedplots in isolation or by surrounding them with a shelterbelt of identical material at least six rows (± 20 meters) deep. Studies on pollen dispersal[11, 43] have shown that appreciable quantities of windborne pollen can be detected at a distance of 100 meters, downwind, from a Robusta orchard in full bloom. Consequently, a distance of at least that size is required for giving a seedplot a reasonable protection against contamination by intruder pollen.

The four or five years required for a seedplot to come into full bearing are, in a way, time lost in waiting. This

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disadvantage can be reduced by laying out, right from the start, when systematic crosses between superior clones are initiated, an orchard in which all these clones are planted as a mixture, according to a definite system. As soon as the test-cross progenies have been evaluated, clones that do not come up to the standards are removed and only those are kept which combine outstandingly. In the most extreme case, there are only two of them, but it is also possible, even often desirable, in order to avoid one-sidedness, to keep four or five clones, provided they flower simultaneously and combine well mutually.

The composition of such a seedplot, therefore, is steadily improved. Seed from it can be utilized from the moment bearing starts. It is true that seed harvested in this first period is not of the best possible composition, but it is considerably better than entirely illegitimate seed. This principle has also been adopted in the Belgian Congo.

Progress obtained by breeding

Although undoubtedly considerable progress has been achieved by breeding it is difficult to express it in exact figures, because there are only few comparative trials in which the original unselected material has been included as a check.

Where such a comparison can be made, one comes to the conclusion that the best illegitimate progenies from clones yield about twice as much as the original unselected seedlings. For single or multiple crosses between outstanding clones which have been found to exceed the best old illegitimate seedling families, the progress is still higher.

As yields vary considerably from district to district, it is of little use to mention figures.

To give an impression only, it may be stated that the multiannual average of the topmost illegitimate clone-derived seedling strains may be put at approximately 16 quintals per hectare in their districts of origin.

Testing for local adaptability

Outstanding performance of a new variety on the trial fields of an experiment station does not by any means offer a guarantee as to its behavior under other climatic and edaphic conditions. The necessity of trials to assess local adaptability has been emphasized in various countries.[18b, 24, 49]

In Indonesia, a large number of local trials, scattered over the main coffee producing districts, were laid out in the period 1934/1941. It is a pity that many of them were lost during the war and the turbulent postwar years.

In the Belgian Congo, most of the prominent new seedling strains were recently submitted to local testing.[49]

The experience obtained in Indonesia indicates that some seedling strains and, *a fortiori*, clones, are very specific as to their requirements for climate and soil; others display a much wider range of adaptibility. The latter applies to a small number of seedling strains, and also some clones from the Besuki and the Central and Eastern Java Experiment Stations, which performed well in various districts of Java and also in the Belgian Congo.[16, 17, 30, 39]

Belgian Congo

The I.N.E.A.C. experiment station at Yangambi started an extensive breeding program in 1934. It had at its disposal a very diversified stock of Robusta types collected at their original habitat, supplemented by improved seedling strains and clones imported from Java.[46, 49]

Mother plants were selected and submitted to a progeny test. For this purpose seed was taken from small monoclonal plots scattered through a rubber plantation. As the distance between these plots was not large enough to exclude interpollination, the seed thus obtained was, in fact, illegitimate instead of legitimate, as had been intended. In retrospect, this is an advantage rather than a disadvantage, as the seed now obtained is, more or less, similar to that obtained by topcrossing or polycrossing. The progeny test (4 replicates, plots of 66 trees) revealed 7 progenies which, averaged over 4-7 years, outyielded the check-clone S A 34 by 15%-35%, whereas the other properties, such as bean size and liquoring quality, were also favorable. These outstanding mother trees (or, rather, their clones) have been intercrossed artificially in every possible way in the years 1955/56. The progenies thus obtained have been put into a replicated comparative trial which, within the next 6-8 years, will yield the data necessary for making out which partners have given the very best progenies—in other words, excel in specific combining ability.

In order to save time, a number of seed-orchards have been laid out, containing the clones under test. Some of them are biclonal, others polyclonal, the latter ones to be thinned according to the results from the progeny test just mentioned. In the late thirties the Yangambi station had already decided to lay out a number of polyclonal seed orchards to meet the planters' demands for seed of good quality. They contained a fairly large number of clones of good general appearance, but at that time not yet evaluated as to their breeding value. During the period the seed orchard grew up, data from a progeny test gradually became available, enabling elimination of clones below standard as breeding partners. So the composition of these seed orchards gradually improved.

The seed thus obtained is called "seed from a standard clonal mixture." The yielding capacity of this material is estimated at 800-900 kg/ha against 478 kg/ha for the old unselected seedlings. Plantations grown out of seed from the polyclonal mixture of the seven outstanding clones mentioned above are expected to have a yielding capacity of around 1,200 kg/ha. For progenies of superior biclonal combinations, the expectations are still higher: plm. 1,400 kg/ha, which means a considerable progress indeed.

French Equatorial Africa

At the Akandje Experiment Station, one of the branches of the Centre de Recherches Agronomiques at Bingerville (Côte d'Ivoire), a modest Robusta breeding program has been in progress since 1945, in continuance of previous work performed at the Man sub station.[15, 7]

In addition to a mass-selection procedure applied to material obtained from the Belgian Congo (I.N.E.A.C.), a

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2. Canephoras (Robustas)

slower pedigree breeding program has also been carried out by raising and testing progenies obtained from artificial self pollination. Variability of bean dimensions of mother trees and their selfed progenies were found to be strikingly similar.

Recently a tentative program for intensifying Robusta breeding in French Equatorial Africa was drawn up by Maistre.[31] The breeding procedures described are, to a large extent, similar to those already applied in Java and Belgian Congo.

Uganda-Protectorate

Testing of progenies of mother trees, selected in long established native plantations, clearly demonstrated that the spreading types, especially from their sixth year onward, yield better and are more drought-resistant than erect types. They are also better suited to the method of training trees into a multiple stem shrub as is customary in Uganda.[47, 35]

Productive families, though still variable in bean size, have been developed. A second breeding cycle has been initiated, starting from mother trees selected from the outstanding families just mentioned.

3. Selection of Clones

The oldest method of vegetative propagation is by means of cleft-grafting;[5, 10] more recently methods for obtaining rooted cuttings, already known in Arabica cultivation, have been adapted for Robusta and allied species.[26, 40, 48]

Clones have two striking advantages over seedling-strains: ,a) Being exact replica of their respective mother plants they are absolutely uniform and easy to maintain; (b) the time required for developing a clone is shorter.

Taking these two advantages into account, one would be inclined to follow the easier and more efficient way and concentrate upon developing clones rather than seedling strains. Such an attitude, however, would mean oversimplifying the matter. In the first place, it is not by any means sure that an outstanding mother tree will yield an excellent clone. Experience in Java gained from extensive material has taught that less than 5% of the mother trees selected result in a really good clone. One further lesson learned by bitter experience is that monoclonal planting should be avoided, as the pronounced self-incompatibility will exclude virtually all fruit setting within plantations of this type. Only in mixtures carefully composed will clonal material show to full advantage. Prerequisites are: simultaneous flowering, inter-compatibility (for cross-incompatibility also occurs), similarity of bean size and shape. Collecting these additional data adds a few more years to the time required for selecting and evaluating clones.[9, 10, 22, 24 25]

Testing of clones is done in narrow plots, often a single row, in order to insure cross-pollination. Randomization and a sufficient number of replications (at least three) are essential. Records should cover a period of five years at least.

Despite the fact that clones or clonal mixtures have been obtained which outyield the best seedling strains, this material has not yet found general acceptance for commercial planting, not even in Java, where the longest experience with clones had been gained.[20, 42, 44] The use of clonal material has been restricted there to two purposes: (a) as an aid in breeding improved seedling strains; (b) as an efficient means of improving seedling-plantations by top-working the potentially poor yielding individuals or by restoring damaged trees.

Research workers and planters in Java[3, 27, 33] are to be credited for a clearer insight into the potentialities of the different types of budwood.

It was found that orthotropic watershoots are not the only suitable grafting-material but that a distinct type of lateral branch growing slightly upwards (at an angle of about 70° with the main axis) and developing secondaries at an early age has positive advantages as a source of scions for top-working. The grafts made with this type of budwood grow faster, fill gaps earlier and are more precocious than those of the traditional type. A restricted number of excellent clones, showing to full advantage when propagated by means of this second type of budwood, have been developed.

Healthy but poor-yielding individuals among seedling populations can be converted into prolific shrubs by top-working them with scions of the second type.[28, 45] Selective top-working carried out systematically and thoroughly must result in a considerable improvement which, however, is difficult to demonstrate by exact figures, as untreated check plots in most cases are lacking.

Plantations treated as just described improve so strikingly in general appearance, as well as in yield, that there is no reason to doubt the effectiveness of this method.

From the frequency distribution of individual tree yields, the progress to be expected from top-working is estimated at 30-35%.[4, 13]

It is quite probable that in a more advanced stage of the breeding work more emphasis will be placed on the improvement of bean shape or size and liquoring qualities. Properties of this kind can be more easily fixed in a clone than in a seedling strain.

4. Interspecific hybrids

Members of the *Canephora* group have served as partners in a few interspecific hybridizations. One category: spontaneous crosses between *C. canephora* var. ugandae and *C. congensis* Pierre have found acceptance in commercial planting in the former Dutch East Indies. For priority reasons, the name "congusta" originally proposed by Cramer[6] should be preferred to the name "conuga" by which these hybrids are known in Java. As these hybrids never breed true to type, they can only be maintained by vegetative propagation (grafting). Congusta is not decidedly self-incompatible, although seed is more readily set from foreign pollination. Consequently planting of clonal mixtures is preferable.[12]

Particularly in high moist mountainous regions, where Robusta does not thrive, Congusta clones have performed satisfactorily, giving yields never attained by Robusta under such conditions. Even at an age of three years, Congusta can bear a reasonable crop.[2, 29]

The Uganda x Congensis cross was later performed artificially in Indonesia[29] and in the Belgian Congo.[18a] From the series mentioned first, a number of promising new clones

have resulted which, owing to the war, did not get the opportunity of being introduced into commercial planting. In various countries—Brazil,[20, 22] Belgian Congo,[18a] India,[1] Indonesia[18]—hybrids between *Canephora* and *Coffea arabica* have been obtained either by artificial crossing or spontaneously. They have nowhere passed beyond the stage of experimentation. A disadvantage generally encountered is the high percentage of peaberry and of seeds with a defective endosperm (spongy beans). Backcrossing with Arabica slightly raised the fertility. Fertile 66-chromosome Arabica-Robusta amphi-diploids obtained by colchicine treatment, have been reported by Brazilian research workers.[20, 22]

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3. ASEXUAL PROPAGATION OF COFFEE

By L. M. FERNIE, Horticulturist
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Lyamungu, Moshi, Tanganyika

Introduction

Asexual or vegetative propagation means the formation of a separate plant from a part of a single parent plant. Investigations into methods of achieving this have been carried out in most coffee-producing countries, primarily for research purposes, and literature on the subject is extensive.

A comprehensive review of all aspects was compiled by Feilden (1940), and more recently, reviews by Guiscafré-Arrillaga (1946) and Fiester (1957) on cuttings, and by Coste (1955) and Haarer (1956) have been published.

The two most widely cultivated species, Arabica (C. *arabica* L.) and Robusta (C. *canephora* Pierre ex Froehner) have both been the subject of these investigations. An important distinction between the two is that Arabica is self-fertile while Robusta is self-sterile.

The reasons for asexual propagation

A plant propagated by asexual means is an exact replica of its parent plant. The method thus affords a means of obtaining genetically uniform material, and this may be considered to be its primary advantage.

The heterogenous nature of Robusta seedlings in Java (Ferwerda—1932) and of Arabica seedlings in Tanganyika (Haarer—1956) has been shown. On the analogy of other crops, it was reasonable to assume that considerable improvement in such plant material could be effected by invoking the use of vegetative propagation as a necessary adjunct to breeding and selection programs. Further, the use of clonal material makes precise field experimentation more accurate.

Dutch workers in Java were reported by Ferwerda (1932, 1934) to have claimed the following additional advantages for vegetative propagation by grafting:

1. Uniformity of habit and of size of berry and bean.
2. Simultaneous cropping of plants within a clone.
3. Possibility of obtaining economic coffee plantations on nematode-infested soils by means of grafts on resistant rootstocks.
4. Possibility of improving existing seedling plantations by top-working inferior plants.
5. Possibility of perpetuating a desirable variety.

Material for asexual propagation of coffee

The economic species of coffee possess two types of vegetative growth, the upright orthotropic shoots and the horizontal plagiotropic lateral branches. A third type is sometimes found having a form intermediate between the two and is really an upward growing lateral branch.

All types can be successfully rooted as cuttings or used as scions. An upright shoot, as an extension of, or as a sucker derived from, the main stem, gives normal upright growth when rooted as a cutting or used as a scion for grafting; similarly, cuttings or grafts of lateral branches maintain a lateral growth habit and develop into flattened shrubs. Grafts from the intermediate form are reputed to produce plants which are noted for their strong development.

Carvalho, Krug and Mendes (1950) insist that differentiation into plagiotropic and orthotropic shoots is permanent and irreversible, and this is generally accepted, although assertions to the contrary have been made by Marshall (1935) and Narasimhaswamy (1946).

Methods of asexual propagation

The production of roots has been achieved by layering, etiolation, and marcotting before severance from the parent plant, but these methods have generally been discarded. The greatest attention has been paid to the rooting of stem cuttings and grafting.

Cuttings

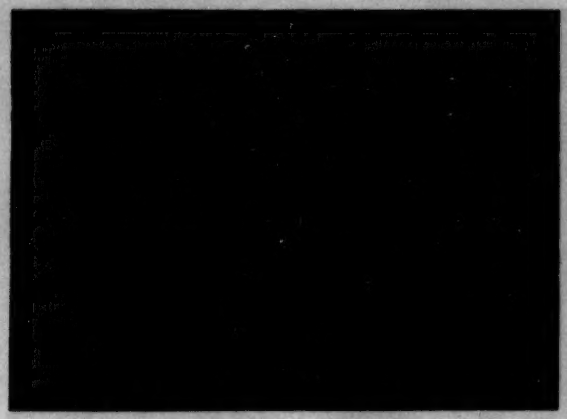
Successful rooting of large cuttings of Robusta by natives is reported from the Ivory Coast by Portères (1935) and from Uganda by Thomas (1940), but as a general rule hardwood cuttings have not been so satisfactory as softwood cuttings, to which the greatest attention has been paid.

With modifications due to climate and local conditions, the basic methods evolved at Lyamungu Coffee Research Station in Tanganyika for the rooting of softwood cuttings (Fernie, 1940, 1950, 1951) appear to have been fairly widely adopted.

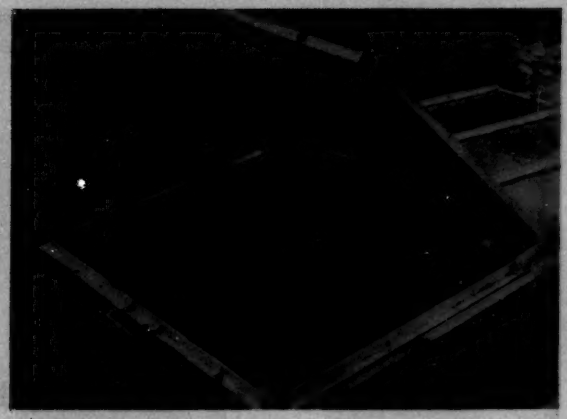
A large number of cuttings can be produced by establishing a mother-tree nursery, where one plant can yield over 100 cuttings a year (Allnutt—1940).

The use of glazed but unheated propagating frames is generally considered necessary, with particular attention being paid to light, temperature, humidity, drainage and the rooting medium.

Apical cuttings of three or four nodes, with a proportionate amount of healthy foliage, preferably trimmed, and semi-hard at the base, are preferred in Tanganyika, and with the tops pruned in Puerto Rico (Guiscafré-Arrillaga—1946).



How stems of plants in the mother-tree nursery are pegged down for the production of suckers to be taken as softwood cuttings.



Cuttings set in the rooting medium in a propagating frame.

The use of single-node cuttings is, however, fairly widespread and is more economical of material.

Rooting has been improved by splitting the base of the cutting longitudinally; internodal positioning of the basal cut is favored in Tanganyika.

Variable results have been reported from the use of hormone root-stimulating substances. This may in part be due to the use of such substances before the full unaided rooting technique has been established. Their main advantage is likely to lie in hastening the rooting process.

The time taken for cuttings to root varies according to locality from one to six months, with an average of three to four months. Rooted cuttings are potted-up for hardening-off when roots a few inches long have been produced.

Budding and grafting

Although up to 90% success has been obtained by shield-budding, using the "T" and inverted-"T" methods of insertion (Feilden—1940), it has never been as favored as grafting, probably due to the greater ease and success of the latter method.

Successful stem grafting has been reported on seedling rootstocks under nursery conditions by use of the cleft, saddle, side, notch, rind, whip, herbaceous, and inarching methods. Of these, the cleft graft has been the most universally employed, preferably during the dry season. The waxing or protecting of the unions is not generally necessary and is even considered undesirable in some places, but a cover of glass, waxed paper, or polythene appears to be essential to prevent the grafts from drying out.

On a small scale in Tanganyika, success has been more certain and the operation made easier when the seedling rootstocks have been lifted, grafted at the bench, and planted in a glazed propagating frame.

Successful root grafting has been achieved by Gandrup (1936) and by Evans (1955).

Top-working direct on to old stamps in the field presents certain difficulties, which are overcome by grafting on to suckers arising low down on the stumps. Sometimes in Java a sucker from the top of the stem was used, and this was grafted with a scion from a lateral.

Rootstocks

It is generally agreed that the greatest success has been achieved when stock and scion are closely related (Gillett—1936: Schweizer and s' Jacob—1938), although Portères (1939) claimed that Arabica was more adaptable than other species, while Ferwerda (1932) showed that some Robusta clones did not succeed on Robusta stocks.

Symptoms of incompatibility are yellowing of the leaves and failure to grow, shedding of the foliage in dry weather, die-back of the branch tips, and abnormal swelling at the union (Haarer—1956).

Instances of degrees of incompatibility are reported from Java by Schweizer and s' Jacob (1938) using Robusta scions, while Cramer (1934) considered that a vigorously growing hybrid was easier to graft than the species.

It was reported from Kenya (Feilden—1940) that none of the many imported and indigenous plants of the order *Rubiaceae* had been found compatible with coffee, but Chevalier (1931) instances a report of successful grafts of Arabica on to *Gardenia*.

Portères (1939) claimed that Arabica on Robusta or Excelsa seems to take on the characteristics of the stock as regards time of flowering and ripening.

In Kenya it was reported by Feilden (1940) that a number of varieties of Arabica as rootstocks failed to influence Arabica scions. Marked reactions, however, were noted when Arabica was grafted on to other species.

Several authorities state that the influence of the scion on the stock is more potent than that of the stock on the scion.

Ottolander in 1899 (cit. Feilden—1940) claimed that Arabica scions reduced the vigor of the root system of Liberica rootstocks and changed the color of the roots. He also claimed that an upright scion produced a deeply penetrating taproot, whereas the root system of those grafted with laterals developed an abundance of lateral roots and only a short taproot.

de Ligt (1936) reported that Robusta scions grew strongly on Arabica seedlings, and that the application of Robusta and Conuga scions transformed weakly Arabica stocks as well as benefiting the scions.

Snoep (1940) found that scions had a marked rejuvenating effect on the root system.

Application of asexual propagation methods

Ferwerda (1934) reported that a considerable grafting program was carried out on plantations in Java, but the cumbersome nature of the method prevented its popularity.

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Stages in the root development of an apical softwood cutting. Note short internodes and older leaves trimmed.

Rooted cuttings in pots of banana fiber for hardening-off.

Later, the same author (1948) stated that top-working was finding increased favor as a means of improving seedling plantations of Robusta, and the results were striking. He also details in the same paper the considerable part that vegetative propagation was playing in the breeding and selection program in Java.

The general possibilities of vegetative propagation of coffee were reviewed by Mayne (1939) before a technique for rooting cuttings had been established.

Thomas (1940) considers that asexual propagation of Robusta in Uganda is unlikely to be of much importance except for special purposes.

Coste (1955) is of the opinion that propagation by cuttings might well replace the normal methods of seed propagation

In Tanganyika, (1955) trials comparing the yields of seedling (open pollinated) and clonal progeny of the same Arabica mother-trees failed to show any differences. As a result of this finding, the use of clonal material in a replanting scheme for African growers was abandoned.

Krug and Carvalho (1952) state that large-scale vegetative progagation in *C. arabica* is not practiced in Brazil and would only be used to propagate some exceptional hybrid combinations. They consider, however, that selections of self-sterile species, such as *C. canephora,* must be propagated either vegetatively or by seed obtained through controlled pollination between highly selected clones.

Summary and conclusions

Techniques for the rooting of softwood cuttings and for the grafting of coffee have been successfully established. Where the latter method is considered desirable for a particular purpose, further information on rootstocks appears to be necessary.

The main uses of asexual propagation methods are as aids to selection and breeding programs and for greater precision in the evaluation of general field experiments at research stations.

The methods are likely to be of greater assistance in the improvement of material of the self-sterile *C. canephora* than they are of the self-fertile *C. arabica.*

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★ **Advances in Coffee Production Technology**

mineral nutrition: high fertilizer applications and their effects on coffee yields

By BRUCE J. COOIL and EDWARD T. FUKUNAGA

This article is published with the approval of the Director of the Hawaii Agricultural Experiment Station as Miscellaneous Paper No. 100.

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The most intensive fertilization of coffee in the world is undoubtedly that practiced in Hawaii. Keeler *et al.*[10] made a study of 15 farms representing a fairly typical cross section of coffee farmers in the Kona District of Hawaii. Among the farms studied, the rates of fertilization exclusive of lime application ranged from 778 to 3,167 lbs. per acre.[a] The average rate for these farms was 1,860 lbs. per acre. Among the 15 farms, 8 received fertilizer at a rate of one ton per acre or higher during 1955.

There is considerable evidence that high rates of fertilization are necessary to sustain the yields obtained in the Kona District of Hawaii. Marked yield responses to nitrogen and potassium fertilizers have been reported by Dean and Beaumont[6] and by Ripperton *et al.*[15] Among the 15 farms studied by Keeler *et al.* there was a significant correlation between yield and amount of fertilizer applied.

Aside from the experimental demonstrations of yield responses to fertilization, the nutrient requirements of high yielding trees have been illustrated by other means. The amounts of fertilizer constituents contained in the coffee crop have been estimated. Ripperton *et al.*[16] estimated that 150 cwt. of cherry coffee contain about 95 lbs. of nitrogen, 18 lbs. of P_2O_5 equivalent, and 101 lbs. of K_2O equivalent. Therefore, an acre of land yielding this quantity of coffee has removed from it in a crop the nitrogen and potassium equivalent to that supplied in about one-half ton of mixed fertilizer containing 10% N and 10% K_2O equivalent. This is, of course, without considering any loss from the land due to leaching or runoff. It is also evident that sufficient supply of these elements must be at hand at the appropriate times if vegetative growth is to be sustained.

That yields of 150 cwt. of cherry coffee per acre or more are frequently obtained on Kona farms is illustrated in the data of Keeler *et al.*[10] When the parchment yields reported by these workers are converted to cherry coffee by use of a factor of four, the mean yield for the 15 farms was 108 cwt. per acre, and three of the farms had yields greater than 150 cwt. per acre. Dean and Beaumont[6] reported yields as high as 249 cwt. per acre for the 1936-1937 harvest season in an experimental plot on a Kona farm, although the yield from the same trees the following year was only 77 cwt. per acre. However, data to be presented later show it is possible to maintain yields well in excess of 150 cwt. per acre each year over a period of at least four years. These yields appear to be of a higher order of magnitude than some yields reported from experiments elsewhere.[12-13-14] Perhaps it is for this reason that Haarer[9] has expressed disbelief in yields reported from Hawaii. When average national yields for good crop years are calculated from acreage and production reports for several countries,[7-10] the data shown in Table 1 are obtained. The ten-year average yield for Hawaii calculated on the same basis is shown for comparison.

Table I. National average yields from several countries during good crop years compared with average yield from Hawaii.

County or territory	Crop year	Average yield cwt. cherry per acre
Brazil	1952-1953	15
Colombia	1955-1956	21
Mexico	1954-1955	17
El Salvador	1954-1955	31
Angola	1953-1954	27
Hawaii 10-year average	1947-1957	98

From the nutrient element content of the crop alone, it is evident that factors which favor high yields also impose high fertilization requirements. Coffee in Hawaii is grown without shade. The most generally used pruning system is the multiple vertical system. When used as regular practice, renewal of young bearing branches is assured by this system.[2-8] Spacing is commonly 8 feet to 10 feet between trees, although closer spacing at the lower elevations (below 1,000 feet) and wider spacing at elevations in the neighborhood of 2,000 feet are used.[15] These practices—sun-grown coffee, regular pruning, and close planting—are all relevant to the yields obtained.

A climatic factor contributing to high yields in Kona may be the rainfall pattern. Periods of low rainfall are typical in the months of November through February, but months with no rainfall are rare.[2-15] This pattern contrasts with the rainfall distribution in the coffee growing areas of Brazil, where no rain may fall for several months. Yield responses to mulching reported by Medcalf[18] suggest that lack of sufficient moisture may seriously limit yields in Brazil.

Another factor contributing to high fertilizer requirements

[a] On most farms a mixed fertilizer with a formula of 10-5-20 was used. In a few cases the figures given include some supplementary ammonium sulfate (21% N).

Table 2. Coffee yields from experimental plots at Kona Branch Station (5)

Treatment	Nitrogen application: Lb. N per acre each year	Nitrogen application: No. of applications each year	Potash application: Lb. K_2O per acre each year	Potash application: No. of applications each year	Yields (cwt., cherry coffee per acre): 1954-1955	1955-1956	1956-1957	1957-1958
F	177	2	724	2	155.4	152.8	121.5	185.1
L	355	2	724	2	170.9	158.6	123.9	172.9
I	355	10	724	2	173.6	199.0	168.4	192.9
K	355	10	724	4	148.6	161.9	139.6	——

in Hawaii is the porosity of the soils in which coffee is grown. These soils are all of volcanic origin, but differ greatly in the proportion of ash and lava rock from which they are derived. The fine soils originate from volcanic ash which ranges in depth from several feet to complete absence. Much of the coffee is grown on lava rock with little or no ash mantle. Undoubtedly, much of the fertilizer applied is leached out by rains.

A number of workers have studied the nutrient element composition of coffee leaves.[3-4-11-12-13-14] Chaverri *et al.*[3] have reviewed data reported by workers from several countries and provided tentative classifications of high, medium, low and deficient ranges for a number of the essential nutrient elements. Loué[12] has given similar tentative ranges denoting adequacy or deficiency of potassium. Results from the Hawaii experiments[4-5] suggest that particular attention to tissue composition during the flowering season may be of value under conditions of high fertilization.

The biennial bearing tendency of coffee in Kona has been the subject of considerable concern on the part of Beaumont and coworkers.[1-2-6] Biennial bearing is illustrated especially by the results of Dean and Beaumont.[6] Solution of this problem has been the objective of various pruning and fertilizer experiments reported by Beaumont and Fukunaga.[2] Beaumont[1] presented evidence indicating that heavily bearing trees produce only limited growth, hence the bearing surface for the following year is small. Data presented by Cooil[4] indicate that during a year of heavy production, leaf concentrations of potassium, nitrogen and starch decrease to low levels. At the end of a season of heavy production, one or more of these elements may limit production the following year. It was also noted that about half the accumulation of dry matter, nitrogen and potassium in the fruit may occur over a period of only two months. Hence, the drainage of these constituents from the vegetative parts of the tree may be rapid as well as great in quantity.

Some results from an experiment at the Kona Branch Station indicate that large fluctuations in yields from year to year can be controlled to a degree by applying nitrogen fertilizer at frequent intervals throughout the year. Although details of this experiment are reported elsewhere,[5] results for some of the treatments are shown in Table 2. These data illustrate the importance of timing in fertilizer application. There was little or no benefit derived from doubling the rate of nitrogen application when all the nitrogen was applied in two applications (compare treatments F and L). However, when the nitrogen was applied in ten applications throughout the year in Treatment I, significant yield response resulted, and the degree of fluctuation from one year to the next was reduced; e.g. although other treatments showed relatively low yields for the 1956-1957 year, yields in Treatment I were maintained at a reasonably high level. Comparison of Treatments I and K shows, however, that benefits to be derived from frequent nitrogen applications are not realized except under specific timing practices with respect to potassium application. It is apparently necessary to apply a large amount of potassium before the flowering season, to obtain the benefits from frequent nitrogen application. The nitrogen concentration in the leaves during the flowering season was highly correlated with yield in this experiment.

The results above indicate that timing of fertilizer application is an important factor in maintaining high yields year after year. Although much further experimentation is needed in this area, the nutritional composition of the tree at flowering time appears very important. In the coffee areas of Hawaii, where some rainfall can be expected at all seasons of the year, it should be relatively easy to regulate the nutritional composition of the tree. In areas characterized by long dry seasons, such regulation may be more difficult.

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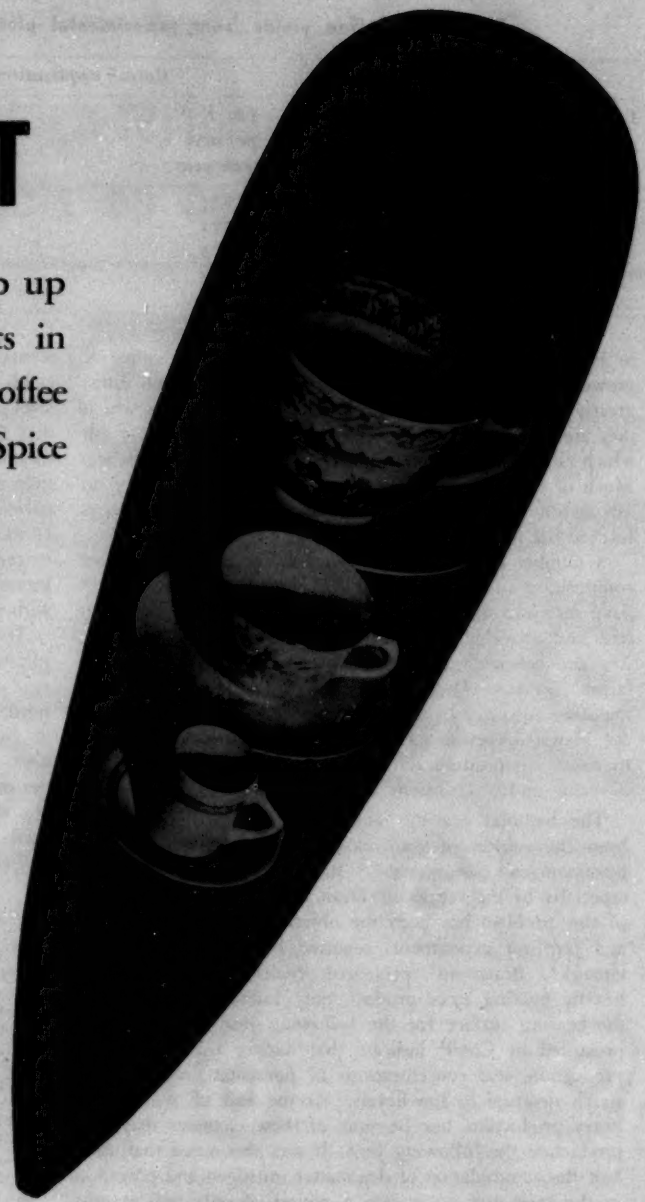

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mineral nutrition: detection and control of minor element deficiencies

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It is well known that any plant needs for its normal development a constant and balanced supply of nutrients, the essential elements. As soon as one of these is lacking or its concentration in the growing medium is too low to supply the needs, abnormalities in growth and development of the plant occur, commonly called deficiencies. If a deficiency is severe, malnutrition effects, in the form of visual symptoms, such as chlorosis, deformation of leaves, stunted growth and die-back, become evident. At this stage the yield of a plant is greatly reduced.

A deficiency of one element always produces the same characteristic and well-defined symptoms which, however, may be different in different plant-species or varieties. Knowledge of these symptoms permits steps to be taken to correct the deficiency and to restore the normal nutrition of the plant. Some plants, like coffee, show such symptoms more frequently and readily, whereas others are less affected by the lack of an element, although growing under identical conditions.

If visual malnutrition signs appear, the deficiency is advanced. Usually the productivity of a plant is already affected when the level of a nutrient has not yet dropped below the "critical" level, beyond which visual symptoms appear. Leaf analysis has proved to be a very valuable tool for detecting incipient deficiencies and for helping to control corrective measurements. In recent years, the method of foliar diagnosis, already used extensively in many other crops, has been employed successfully in different parts of the world to assess the nutritional status of coffee trees and to determine fertilizer needs.[6, 8, 9, 10, 36, 39, 40, 47, 52, 53, 75]

Nitrogen

Coffee growing requires a good supply of nitrogen in the soil. As soon as this element is deficient, the leaves turn light green to yellow, are slightly smaller in size, and growth is often reduced.[2, 9, 21, 29, 38, 43, 52, 56, 74] Sunlight intensifies the chlorosis considerably[9, 52] and high light intensities seem to have a negative effect on nitrogen accumulation in leaves.[37, 73] In areas where coffee is grown without shade, a higher amount of leaf nitrogen is necessary (3% or more[47a]), partly because of the larger crop produced, than in areas where cultivation under shade is standard practice (2-3%).[8, 17, 39, 40, 52]

The amount of nutrients present in coffee leaves varies according to the season of the year.[6, 8, 33, 35, 39, 47, 52] It is therefore difficult to give an average "normal" leaf content of nitrogen; one has to consider its annual variation when estimating the nutritional status of a coffee plant. From the seasonal data available,[6, 8, 33, 35, 39, 47, 52, 69] it can be said that, after a long dry spell, the nitrogen content of the coffee tree increases rapidly with the beginning of the rains; usually this period coincides with new growth and flowering. Thereafter the nitrogen content decreases constantly as the fruits develop. Nitrogen deficiency symptoms are therefore predominant after the cropping is over, as well as during the dry season when soil nitrogen is not readily available to the plant.[52, 59, 60, 61]

In areas with low annual rainfall, heavy mulching has proved to be very beneficial in reducing the chlorosis during the dry season,[61, 62] probably because the increased soil moisture permits the tree to take up more nitrogen. Shortly after a heavy application of mulch, additional nitrogen fertilizer may be needed to compensate for the initial negative effect of mulch on total available nitrogen.[28, 48]

Fertilizer practices vary in different countries. However, it seems to be generally accepted that there exist two periods when nitrogen fertilizer is most needed: at the beginning of the rainy season, when flowering and growth start; and toward the end of the rainy season, or when the fruits are maturing.[35] The latter application is especially important in building up enough nitrogen reserves in the tree to prevent deficiency during the dry season.[6]

Coffee responds readily to nitrogen applications where the amount of this element in the soil is inadequate, and in many coffee-growing areas, nitrogen fertilization is routine practice, although its beneficial effects are not always realized.[35, 63] Nitrogen is applied to coffee in many different forms of fertilizer. Urea is the form in which it is most

a. *Analytical data for the elements given in this publication are in percentages on the dry weight basis. Since the amount of nutrients varies with the age of the leaf, it is generally accepted that the third or fourth leaf pair (from the tip) be selected for analytical purposes.*[31] *Leaves in other positions may need to be analyzed where deficiency symptoms occur.*

Mineral nutrition

Detection and control of minor element deficiencies

readily available to the tree, whereas ammonium sulphate provides a much slower-acting source with longer-lasting effects. The kind of nitrogen fertilizer to apply depends largely on the soil type. Sodium nitrate and urea are preferred in very acid soils,[34] whereas ammonium sulphate is recommended on less acid soils.[44, 70]

Lately, attempts have been made to supply nitrogen to the coffee tree by foliar application. Absorption of urea by the leaves is rapid,[7] and the nitrogen is apparently readily utilized in metabolism,[42, 77] but there exist some exceptions to this experience.[48] More research is needed on the value of urea sprays. Care should be taken to apply the urea in low concentration and to use urea of low biuret content, since coffee is sensitive to this compound and toxicity symptoms frequently[54, 77] appear after urea applications, whether as foliar sprays or added to the soil.

Excessive amounts of nitrogen may have a depressing effect on the crop, producing too much vegetative growth.[37, 44, 55, 63] A carefully balanced nitrogen nutrition of the coffee plant is therefore essential in order to ensure good crops.

Phosphorus

Phosphorus deficiency in coffee has been reported only in a few areas,[32, 39, 52] although coffee soils are frequently deficient in this element. The phosphorus nutrition of coffee is not clearly understood. It seems that the tree can readily take up phosphorus even if only small amounts are available in the soil. The element also may be stored to some extent in the tissues of the tree. These facts become evident when attempts are made to produce deficiency symptoms in nutrient solutions, which frequently result in failure.[9, 29, 43, 73, 79] Only a few investigators have reported well-defined symptoms of phosphorus deficiency.[9, 21] When phosphorus is deficient, the oldest leaves become mottled and irregular yellow spots, usually having a reddish tint,[52] develop. Defoliation takes place and the rate of fungus attack is somewhat increased.

The critical level for phosphorus in coffee leaves seems to be 0.1%, below which deficiency symptoms appear. Concentrations as low as 0.03% have been reported under field conditions[52] and 0.12-0.18% of phosphorus seems to be a sufficiently high supply of this element to guarantee a good crop.[8, 40, 47, 52]

Responses to phosphate fertilizer application frequently have not been significant,[6, 18, 24, 39, 40, 44, 61] although sometimes a slight increase in yield or leaf content has been observed.[63, 68, 78] Probably most of the fertilizer is rendered insoluble in the soil, since usually only large dressings have given significant results. Organic manure is probably the best source of phosphorus;[4, 45] bone-meal has also given good response.[76]

There exists a positive correlation between phosphorus and magnesium and phosphorus and nitrogen. If one element is low in amount the uptake of the other elements is affected.

Potassium

Potassium deficiency in the coffee tree is characterized by a necrosis in the oldest leaves, together with a heavy defoliation,[5, 9, 10, 21, 28, 29, 38, 40, 43, 56, 73] symptoms identical with those of many other plant species. Similar effects may also be produced by high salt or soluble fertilizer concentration near the feeding roots, excess of sodium in the leaves, drought, wind and certain fungi. However, chemical analysis of the affected leaves readily reveals the occurrence of potassium deficiency. Usually under field conditions leaves low in potassium are highly susceptible to weak parasitic fungi which increase leaf necrosis and defoliation. It is well known with many other crop plants that a good potassium supply increases resistance to fungus infection.

Severe potassium deficiency is not common in coffee soils, although it is found in many parts of the world.[2, 4, 6, 11, 19, 22, 38, 48, 53] Frequently the amount of available potassium in the soil is not sufficient for the needs of a good crop, and potash fertilizer may have to be applied. Especially in Hawaii, high potash applications are standard fertilizer practice.[1, 11, 33, 64] Coffee trees readily take up potassium from any kind of commercial potash fertilizer[5, 6, 16, 47, 57, 76] but crop response to additional potash cannot be expected if the tree is already well supplied with potassium. It is generally agreed that a leaf content of 2% is high enough to ensure excellent yield, whereas a leaf content below 1.5% may be critical, and deficiency symptoms may appear when the potassium content is below 1%. In very deficient leaves, the potassium content may drop to 0.1%.[10, 17, 33, 39, 40, 47, 73] Luxury consumption of potassium sometimes occurs and an excess of this element in the tree frequently leads to magnesium deficiency.

A positive correlation between potassium content of coffee leaves and starch accumulation has been found,[12, 13, 16, 18] the starch content depending largely on the amount of potassium present. If not enough starch is produced, the new growth is curtailed, resulting in a strong biennial bearing habit.[11] The rate of absorption of potassium by the coffee tree may not always be sufficiently high to counteract the effects of potassium depletion, especially in older leaves. In wet climates, some potassium may even be leached from the leaves by heavy rains.[10, 78]

Calcium

Calcium is found in relatively low concentration in the coffee fruit as compared to the leaves. Since soils usually have a fairly adequate supply of this element, calcium deficiency does not occur frequently, and so far it is known only in Costa Rica[52] and Colombia.[54]

The most typical symptom of calcium deficiency is a

marginal chlorosis of the young leaf, together with dieback of the growing point.[9, 21, 28, 43, 52, 53, 56] The chlorosis is frequently associated with a convex "cupping" of the leaf lamina[20, 52] and with corky growth on the principal veins, especially on the lower surface of the leaf.[52] Calcium is not translocated from older leaves to the new growths, and therefore a constant supply of this element is necessary. There exists some antagonism between potassium and calcium,[6, 8, 9, 28, 40] but it is not as clearly marked as that between potassium and magnesium.

Measures undertaken in Costa Rica to correct calcium deficiency by the use of calcium salts have not been successful, as the uptake from additions of this element to the soil is extremely slow or non-existent.[6, 9, 52, 67] However, some indirect beneficial effect may be obtained through changes of soil reaction, brought about by liming, for instance, in reducing toxic amounts of manganese.[58] Although, in Costa Rica, liming is generally beneficial,[25] good results are not often obtained in other areas.[71] The calcium nutrition of coffee is complex, and further research is needed to elucidate it.

Magnesium

Magnesium deficiency in coffee has been reported from several countries[19, 30, 52, 65] and for many different soil types. It is one of the elements found in relatively high concentration in the coffee fruit, and coffee seems to be sensitive to a low supply of this element in the soil. If deficient, a chlorosis appears in the oldest leaves, which are soon shed. The midrib turns yellow, together with a typical interveinal chlorosis, leaving a small strip of green tissue along the midrib and main lateral veins. Although it is generally agreed that magnesium deficiency affects the oldest leaves first,[9, 20, 21, 29, 40, 43, 52, 65] there is some discrepancy between the symptoms observed in the field[20, 52, 65] and those produced in nutrient solutions,[9, 21, 28, 43, 79] which frequently are not well defined.

Foliar diagnosis is widely used to study the magnesium nutrition of the coffee tree, but there is little agreement as to the limiting amount of this element in leaves, partly because the methods employed in its determination vary considerably. With the thiazol yellow method, a content of 0.2-0.3% appears to be a satisfactory supply, and below 0.1% deficiency symptoms are apt to occur;[9, 33, 52] whereas, if the flame photometer is used, 0.2% seems to be low and deficient.[20, 38] There exists a close correlation between the amount of soluble magnesium present in the soil and the appearance of leaf deficiency symptoms.[52, 66]

A strong antagonism exists between magnesium and potassium. A high concentration of potassium in the soil frequently causes magnesium deficiency, especially if the soil supply of this element is low.[6, 8, 9, 20, 38, 40, 66] A positive correlation can be found between the uptake of phosphorus and that of magnesium, and between nitrogen uptake and magnesium uptake.[9, 20, 40, 49, 66] Sometimes high nitrogen fertilization reduces magnesium deficiency considerably.[66]

In the case of a deficiency, a relatively large quantity of magnesium fertilizer is often needed for correction. For example, in Costa Rica, between 4 and 8 ounces of magnesium salt are usually applied per tree,[66] and in severe cases even higher amounts may be necessary. The response is slow[20, 66] but significant. In areas where deficiency occurs, it may be good practice to include magnesium compounds with the regular fertilizer.

Sulphur

As far as the author is aware, no symptoms of sulphur deficiency in coffee have been reported under field conditions. Since sulphur deficiency is generally not very widespread, and the use of sulphate-containing fertilizers for coffee is standard practice in many areas, deficiency of this element is not likely to occur.

When sulphate is withheld in nutrient solutions, a more or less intensive chlorosis of the youngest leaves develops, similar to nitrogen deficiency.[21, 29, 38, 56] Not enough analytical data are available to determine the normal content of sulphur in coffee leaves.

Iron

Iron deficiency may occur under many different soil conditions.[15, 30, 32, 52] Some areas are seriously affected by the deficiency, which may curtail production considerably.[48] The typical symptoms are a chlorosis of the tissue of the youngest leaves, which may be of light green color to yellowish or almost white in severe cases of deficiency. All the veins, including the smallest ones, remain green (in advanced stages some may also loose their color), giving the effect of a very fine reticulation.[9, 21, 38, 52, 56, 58, 66] Symptoms found under field conditions and those produced in nutrient solutions show good agreement; the same symptoms are also very characteristic in the majority of plants other than coffee.

Iron deficiency may occur in many types of soil, having also different causes. If the deficiency is not severe, and affects especially the youngest vigorous growth (flush), it usually corrects itself when the leaves become older.[38, 52] Frequently, a high ratio $\frac{P}{Fe} = 30$ or above, may be found in the deficient leaves, as compared to normal values of below 25. The possibility that iron deficiency may be caused by excess of phosphorus[20, 52, 74] has been frequently reported also with other plants. In areas where potash is deficient, iron deficiency is also frequent; it disappears, however, after the applications of potassic fertilizers.[54] The situation is more serious if the deficiency is caused by alkalinity (high pH value) such as occurs in calcareous soils, and little chance of correction exists. In cases where the iron deficiency is caused by high soluble manganese in

Mineral nutrition

Detection and control of minor element deficiencies

the soil (manganese toxicity) good recovery is usually obtained by applying lime[58] or organic manure[45] to the soil in order to reduce the manganese content. More recently, metal chelates (½-1 ounce per tree, soil application) have given promising results in Brazil for correcting manganese-induced iron deficiency.[46]

Foliar applications of various iron compounds have always resulted in failure to correct the deficiency, no matter what compound was used.[14, 15, 54, 66] In contrast to the rapid entry of zinc, iron is not absorbed by the coffee leaf.

Leaf analysis for iron is of little value. Besides contamination in the analytical procedure, one has to consider the fact that large quantities of iron may occur in the coffee leaf in a physiologically inactive form. More important than total iron is the ratio of iron content to that of other antagonistic elements, like manganese and phosphorus. It seems that a concentration of 0.007% of iron in the coffee leaf is the critical level below which deficiency may occur, but not many data are yet available to substantiate this claim.[38, 47, 52]

Manganese

Manganese deficiency in coffee manifests itself by two types of visual symptoms, which look quite different. If the deficiency is not severe, the youngest leaves turn pale, and the principle veins, together with a small diffused strip (1-2 mm wide) of tissue on each side remain dark green.[9, 52, 66] The content of manganese in these affected leaves usually lies between 0.0025% and 0.001%. If it drops below 0.001%, the first leaf pairs (from the tip of the branch) are of uniform light green or yellowish color for coffee grown under shade, and bright lemon color for coffee grown in the sun,[25, 56, 66, 72] often with tiny whitish specks between the smallest veins.[52] Leaf analysis reveals an accumulation of nitrogen[20, 52] and especially of potassium[52] (sometimes over 100% increase) in the manganese-deficient leaves. The deficiency is seasonal,[25, 51, 66] being more severe during the rainy season.

Manganese deficiency has been reported from several localities.[19, 28, 32, 52] In Costa Rica, it is frequently associated with low manganese supply in the soil and a soil reaction between pH 6 and pH 7.[52, 66] A high content of organic matter, which considerably decreases the available manganese,[45] may be the reason why the deficiency is especially intense near settlements.[52, 66] The correction of the deficiency is not always simple. In Colombia, soil applications of manganese salts[19] were corrective, whereas in Costa Rica, they have not given good results.[25, 66] Leaf spraying is recommended instead[25, 66] with a solution containing 2-8 lbs. of a manganese-containing compound in 100 gallons of water, together with a sticker. When manganese sulphate is used, the addition of lime is suggested.[66]

Excessive quantities of soluble manganese may cause toxicity in the coffee plant.[32, 46, 58, 66] In this case, the manganese content of the leaves rises from 0.02% to over 0.1%.[46] Whereas manganese deficiency does not severely reduce development and yield of the coffee tree, manganese toxicity is detrimental. Good response has been obtained from lime applications,[58] and from the addition of metal chelates to the soil.[46] In both cases the correction of manganese-induced iron deficiency is involved (see under "Iron").

Boron

Boron deficiency expresses itself by several typical symptoms. The youngest leaves are much smaller, more elongated and deformed, the leaf margin is not symetrical, and the leaf surface is roughened. Die-back of the growing point also occurs and gives rise to multiple branching, starting near the dead tip (fan-shaped branching).[9, 26, 38, 51, 52, 56, 66, 67, 72, 80]

The results of leaf analysis, employed to determine boron needs, require careful interpretation. Since boron is not translocated to the growing point, a constant supply of this element is necessary for satisfactory development. As soon as boron content becomes low in the soil (for example, during a prolonged dry season, or after long rains), the deficiency symptoms develop. When more boron is available to the coffee plant, new growth becomes normal and results in a rhythmical appearance of the deficiency. However, the deformed leaves retain their shape and may constantly accumulate large quantities of boron as they grow older. This tendency to accumulation may rapidly lead to boron toxicity after excessive application of this element in an attempt to correct an existing deficiency. Boron toxicity expresses itself in an intense chlorosis of the oldest leaves. The range between deficiency and toxicity in the case of boron is much narrower than for any other element.

Youngest leaves, before fully grown, become boron deficient if their content of boron falls below 0.002%.[38, 52] In the oldest leaves, amounts in excess of 0.01-0.015%, on the other hand, usually produce toxicity symptoms.[52, 54]

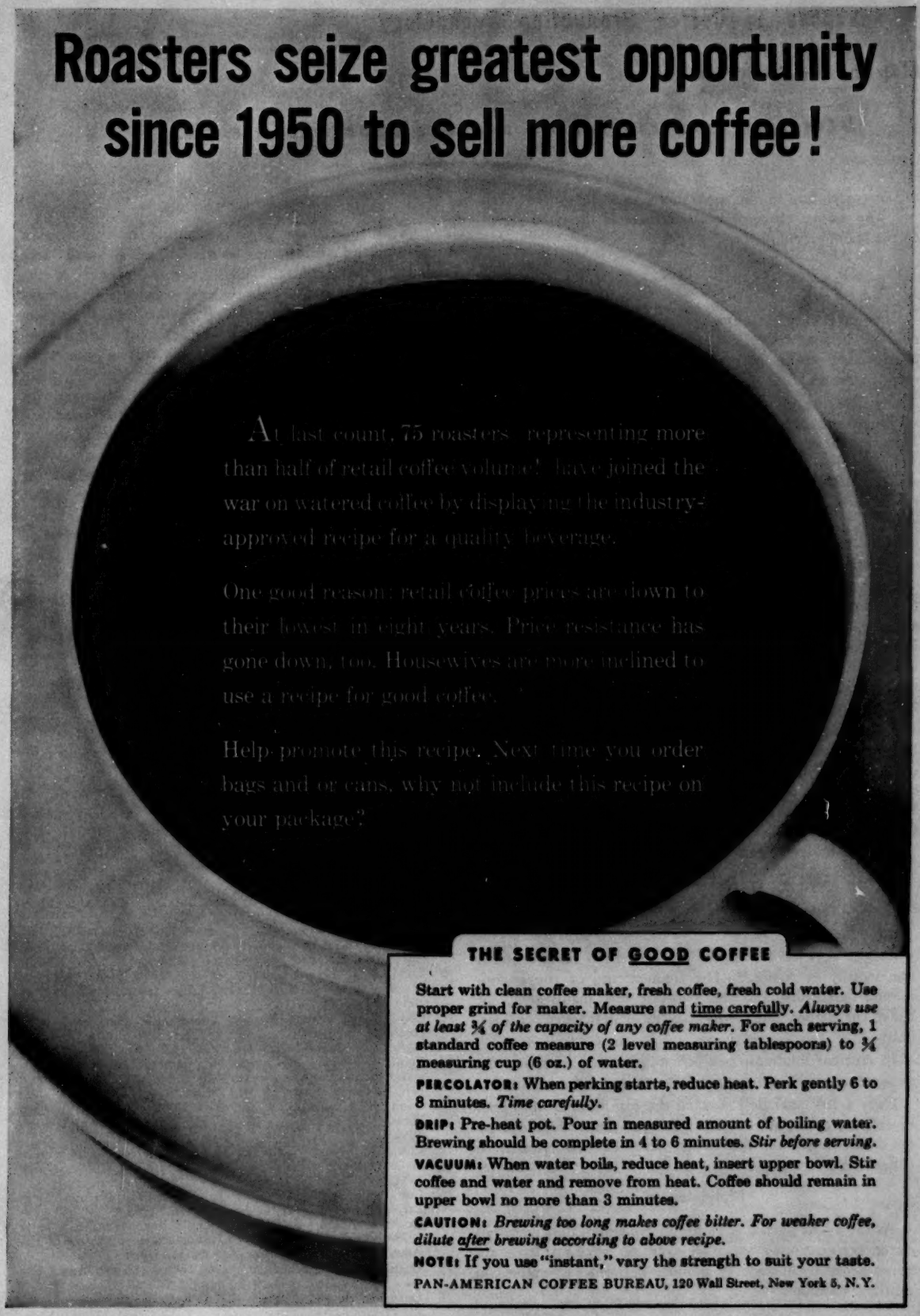
Boron deficiency may seriously affect coffee production, as in Costa Rica.[25, 67] Applications of a few ounces only of a borated compound may increase production three fold.[67] There are two efficient ways of applying boron:[23, 25, 26, 66, 67, 80]

1. Yearly soil application of ½-4 ounces of borate or other boron compound, the amount depending on the intensity of the deficiency.

2. Spraying with an aqueous solution containing 0.2-0.3% of the boron compound with a sticker, once or twice a year. If the product is not neutral in reaction, the addition of lime is recommended.[66] Combination sprays with some fungicides are frequently used.

Boron is taken up within a week after application of boron compounds to the moist soil,[54] but complete correction can only be expected for the new growth following. Regular chemical analysis of the older leaves is a valuable aid for

Roasters seize greatest opportunity since 1950 to sell more coffee!



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THE SECRET OF GOOD COFFEE

Start with clean coffee maker, fresh coffee, fresh cold water. Use proper grind for maker. Measure and time carefully. *Always use at least ¾ of the capacity of any coffee maker.* For each serving, 1 standard coffee measure (2 level measuring tablespoons) to ¾ measuring cup (6 oz.) of water.

PERCOLATOR: When perking starts, reduce heat. Perk gently 6 to 8 minutes. *Time carefully.*

DRIP: Pre-heat pot. Pour in measured amount of boiling water. Brewing should be complete in 4 to 6 minutes. *Stir before serving.*

VACUUM: When water boils, reduce heat, insert upper bowl. Stir coffee and water and remove from heat. Coffee should remain in upper bowl no more than 3 minutes.

CAUTION: *Brewing too long makes coffee bitter. For weaker coffee, dilute after brewing according to above recipe.*

NOTE: If you use "instant," vary the strength to suit your taste.

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use in controlling boron applications so as to prevent toxicity. The normal range of boron content in the older leaves of the coffee tree is 0.006% to 0.012%.

Zinc

Zinc deficiency has frequently been recognized under field conditions.[22, 23, 25, 32, 50, 51, 52, 64, 66, 80] Coffee seems to be especially susceptable to a low concentration of this element in the soil.

Deficiency symptoms may readily be produced in nutrient solutions and are very specific, consisting of small, deformed and lanceolated leaves showing marked chlorosis. The growth of the tree is stunted, and the internodes are short.[23, 25, 38, 50, 52, 56, 66] Excessive die-back may result in early death of the trees. Data obtained by leaf analysis are scarce,[38, 46, 47, 58] but it seems that 0.001% of zinc in the coffee leaves may be the critical level, and 0.0007% definitely deficient.

Since zinc deficiency may greatly curtail coffee production, its control is of great economic importance. In nutrient solution, zinc is much more rapidly absorbed through the leaves than taken up by the roots.[41] Similarly, under field conditions, it is neither effective nod economical to apply zinc fertilizer to the soil, and spraying is a much more effective way of controlling the deficiency.[23, 25, 27, 46, 50]

A solution containing from 0.2 to 1.0% of zinc sulphate, together with lime and a sticker, should be sprayed onto the coffee trees several times during the year, the number of applications depending on the severity of the symptoms. If a neutral zinc product is used, only a sticker is required. Combination sprays with some fungicides are often employed. Absorption is rapid, and complete recovery is usually obtained with the new growth.

Copper

Copper deficiency in coffee has only been reported from one locality in Africa.[32] The frequent use of copper-containing fungicides, and the evidently low requirements of coffee for copper, reduce the chances of deficiency considerably.

In nutrient solutions, lack of copper affects especially the youngest growths, producing deformation and necrosis.[72]

Only a few analytical data on the leaf content of copper in coffee are available,[9, 39, 46, 47] and no conclusions can yet be drawn regarding the critical level of this element in coffee leaves.

Molybdenum

As far as the author is aware, molybdenum deficiency has never been reported in coffee, and no attempts have apparently yet been made to produce deficiency symptoms in nutrient solutions.

Summary

Tropical soils show great variability in composition and properties, sometimes even within a small area of land. Heavy railfalls cause severe erosion of the valuable top-soil and also leach away considerable amounts of nutrients to the deeper soil horizons inaccessible to plant roots. A change in reaction (pH value) may render an element almost insoluble in some soils, whereas in other soils, it may release it in toxic amounts. Since coffee is a plant which is extremely susceptible to nutrient disturbances, the complexity of soil problems causes many severe handicaps to its wide-scale cultivation. Awakening interest in the results of research within the last few years all over the world, however, has made it possible to overcome some of the difficulties involved in the successful growing of coffee. Coffee yields of existing plantations may be greatly increased by the correct use of fertilizers, and by better cultivation methods, and this is especially important when coffee prices are low and the cost of production has to be reduced.

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★ **Advances in Coffee Production Technology**

better control of water supply for coffee production

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Although irrigation of coffee has been practiced for centuries in Yeman,[44] it has only been during the last decade or so that it has received the close attention of coffee scientists and growers in other countries. Interest has been stimulated by favorable irrigation results with other crops and the availability of improved equipment, such as portable aluminum pipe, for commercial installations. Following early trials conducted in East Africa[16, 40, 43, 55] coffee technicians in Brazil, India, Costa Rica and West Africa are now studying the many aspects of this problem[12, 15, 23, 28, 30, 40, 57]

COFFEE IRRIGATION

Inadequate soil moisture is often a major factor limiting production over widespread coffee areas throughout the world. Brazil, traditionally the world's largest producer, has often been plagued by droughts which have seriously reduced yields. Although annual rainfall usually averages at least 45 to 50 inches throughout most of the Brazilian coffee areas, distribution may often be quite irregular.[41] Over the past several years close to 70,000 acres of coffee in Brazil have been brought under irrigation using portable pipe and overhead sprinklers.[7] The complete cost of such systems is now between $75.00 to $100.00 per acre.[49] Increased yields with irrigation in an experiment at Matão, Brazil,[50] over a period of three years paid for the cost of equipment and operating expenses and in addition gave a net profit of about $60.00 per acre.

In the East African coffee areas of Kenya and Tanganyika, inadequate rainfall is an even greater deterrent to the coffee farmer than in Brazil. Annual precipitation totals over considerable areas may average between 25 to 40 inches.[15] This is about half the amounts generally recorded in Brazil. Not only is this quantity marginal for the production of many crops, including coffee, but the variability of the rainfall pattern is high.[21] Furthermore, the dry periods are often accompanied by severe air temperatures and low humidity, resulting in excessive evapotranspiration losses. Interest in the commercial possibilities of irrigation to improve the production efficiency of coffee in these areas is increasing.

Table 1. Climate pattern, Matão, Brazil

Month	*Monthly Rainfall Longterm Mean -inches-*	*Mean Air Temperature °F*	*Potential Evapotranspiration (computed) inches*	*Moisture Surplus or Deficit inches*	*Open Pan Evaporation -inches per day-*	*Solar Radiation Mean daily gm. cal/cm².*
	(A)	(B)	(C)	(D)	(E)	(F)
January	9.6	77.4	5.2	+4.4	0.22	500
February	8.6	76.5	4.3	+4.3	.21	555
March	6.1	75.9	4.4	+1.7	.21	510
April	3.0	72.0	3.1	—0.1	.16	450
May	1.9	67.1	2.2	—0.3	.13	405
June	1.3	66.0	1.9	—0.6	.12	365
July	1.0	66.4	2.0	—1.0	.12	385
August	0.8	69.3	2.6	—1.8	.13	395
September	2.6	73.4	3.6	—1.0	.14	420
October	4.9	74.5	4.2	+0.7	.22	445
November	6.4	74.3	4.2	+2.2	.21	535
December	9.2	75.9	4.8	+4.4	.21	490
Total	55.4		42.5			

Remarks: A—35-year mean, 1925-1957. B—5-year mean, 1953-1957. C—See Thornthwaite.[46, 48] E—1957 data, Australian type, evaporimeter 3 feet diameter. F—3-year means 1955-1957; photochemical method.

Table 2. Irrigation response, Matão, Brazil

Harvest Year	Clean Coffee — lbs./tree 1	2	3	Control	L.S.D. (0.05)
1953	1.17	0.99	0.90	0.67	0.20
1954	1.81	1.82	1.97	2.05	.29
1955	3.14	2.57	1.86	1.39	.46
1956	1.83	1.92	2.25	2.11	.35
1957	3.25	2.69	1.99	2.18	.50
Totals	11.20	9.99	8.97	8.40	1.29

Treatments: 1—Available moisture throughout the year. 2—Available moisture May to September. 3—Available moisture September to February.

Effects of irrigation: on yields

In Tanganyika, at the Coffee Research Station, Lyamungu, irrigation over a ten year period (1942-51) increased yields from 4.57 to 7.20 cwts. per acre, equivalent to a gain of 58%.[38] Irrigation plus mulch improved yields by 95%. During this period annual rainfall ranged from 40 to 100 inches, with a mean of about 60 inches.

Three irrigations and three systems of mulching were compared. Irrigation consisted of supplementing monthly effective rainfall to either two or four inches versus two inches fortnightly. Banana mulches of 40 and 80 pounds per tree at the end of the long rains were compared with 40 pounds applied twice a year.

Irrigation to attain two inches effective rainfall per month together with a 40 pound mulch was the best treatment. Yield differences within any of the levels of irrigation or mulching were, however, slight. The relative responses to irrigation varied greatly from year to year. In 1944, yields were low in all treatments; however, irrigation increased yields fiftyfold over the controls! By contrast, in 1948 the control plots gave almost 16 cwts. as against 12 cwts. for the irrigated plots, which had borne heavily the prior year. Both irrigation and mulching, alone and in combination, reduced but did not completely eliminate biennial bearing.

At the Scott Laboratories, Kenya, Rayner[40] reported almost a threefold increase in mean coffee yields with irrigation over an eight year period (1942-50). These data were collected from small blocks of trees which were utilized for detailed growth and climatic correlations. The average yields of the irrigated and unirrigated trees were 11 and 3½ cwts. per acre respectively. It is interesting to note that biennial bearing was reduced in the irrigated plots.

Irrigation information is available from a semi-commercial installation of 23 acres conducted at Kiambu, Kenya.[42] In this demonstration, irrigation was applied with the purpose of benefiting a heavy crop already on the tree. A single application of 2½ acre-inches was applied as a surface application to basins around each tree. The irrigation was made during the dry winter months, from late June to mid-August. Prior to irrigation, the coffee berries exhibited typical symptoms of water deficit. This was noticeably decreased following irrigation. Coffee yields were raised from 12 to 15½ cwts. per acre, equivalent to a 30% gain. An improvement in coffee quality (liquoring and bean grading) was also reported. Associated with these responses, a net profit per acre of approximately £90 sterling was realized.

In India, Davis[12] mentions the use of irrigation on commercial estates of Robusta coffee. The general practice is to start irrigation soon after the end of the rains in October, to maintain adequate soil moisture until March or April. While no yield figures are cited, the author believes irrigation to be particularly beneficial. Special emphasis is given to the insuring of a good flowering with irrigation. Water applications appear to have been made empirically, with monthly amounts of between one and two acre-inches.

Lazzarini[22] in Brazil reports a twofold gain in yields over a seven year period (1944-50), with irrigation during the dry season, May to September. Mean annual precipitation during the trial was 52 inches, with a range of approximately 30 to 65 inches. This test was located at the Ribeirão Preto Substation of the Instituto Agronomico, in 35-year-old trees on Terra Roxa clay soil.

Irrigation was applied as a surface application to a basin around the tree. Scheduling of irrigation followed a system of applying 3 to 4½ acre-inches of total moisture (rainfall plus irrigation) per month for the period of May to September. For the seven year test period, the irrigated plots produced a mean yield of 430 lbs./acre of clean coffee as against approximately 200 lbs./acre for the controls. Percent gains ranged from 50% to 175% for individual years, depending on the intensity of the drought. During a two year period when measurements were taken, the irrigated plots showed a 17% gain in milling ratio over the controls. Harvests were slightly earlier in the irrigated plots, but biennial bearing remained essentially unchanged.

An irrigation experiment being conducted by IBEC Research Institute at Matão, Brazil[28] has demonstrated a 33% gain in yield over a five year period (1953-57). This test is located in a 30-year-old stand of coffee. Mean

Table 3. Irrigation schedule and rainfall, Matão, Brazil

Year	Irrigation Period	Days	Moisture — inches Rainfall	Irrigation	Total
1952	27 May to 8 October	134	3.4	4.1	7.5
1953	3 July to 3 September	62	1.3	3.4	4.7
1954	3 May to 19 November	200	15.2a	8.5	23.7
1955	7 July to 4 October	89	1.8	7.0	8.8
1956	3 September to 21 November	79	10.6b	3.4	14.0

Remarks: a—8.5 inches of rain occurred in May shortly after irrigation. b—5.5 inches of rain occurred in September shortly after irrigation.

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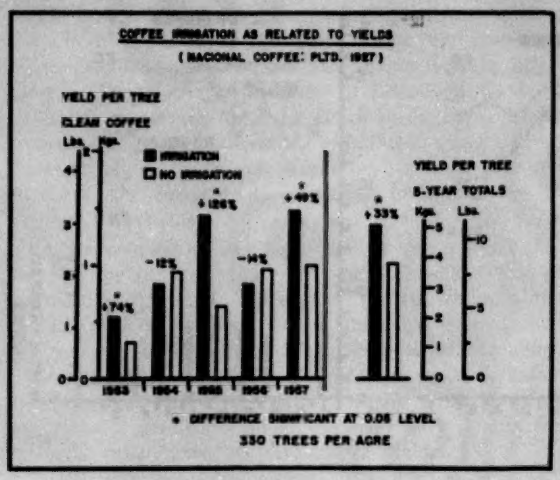


Figure 1

annual precipitation during the trial was 51 inches. Pertinent climatic information is shown in Table 1.

The soil in this experiment is a fine sandy loam with an available moisture capacity in the first three feet of about three to four inches. Most of the root system is confined within this depth, although the greatest concentration is within the top two feet. Irrigation was usually applied when approximately one half of the available moisture in the root zone was depleted.

In this test, the response to irrigation is being compared at three various periods of the year: (1) Throughout the year; (2) May to September, dry season, "preflowering"; and (3) September to February, "post flower and early fruit." Yield responses over a five year period for each of these treatments are shown in Table 2. In Figure 1, the yield for Treatment 1, and the control, are presented. Table 3 shows the irrigation schedule and rainfall during the principal irrigation period for Treatment 1.

The largest yield gains were attained in Treatments 1 and 2. In both instances, the principal irrigations were made during the dry season, May to September. In Treatment 1, however, irrigations were often required as late as November, and in one year out of five years also in February. As shown in Table 2, five year totals for Treatment 1 were just short of being significantly greater than for Treatment 2. The harvests of 1955 and 1957, however, of Treatment 1 proved statistically superior to Treatment 2.

The period of the year covered by Treatment 3 is generally characterized by adequate rains. Dry spells during this time can, however, be severe due to the greater evapotranspirational losses than in the cool winter months of May to September. Over the five year period studied, the rainfall and irrigation pattern was such that this treatment outyielded the controls only on two occasions.

Irrigation did not significantly reduce the tendency of biennial bearing as compared to the unirrigated controls. There was an upward trend in yields in the irrigated plots for the first three years. The two following years, however, showed a return to a biennial behavior. Although flowering was generally somewhat more advanced in the irrigated plots, the date of cherry harvesting was essentially the same as in the controls. This may have been due to a slower rate of fruit ripening on the more leafy irrigated trees. Fruit exposure was generally much less (implying lower fruit temperature) on the irrigated trees than on the sparsely foliaged controls, see Figure 2. Went[53] has reported that the rate of coffee fruit ripening may be significantly retarded by a lowering of temperature.

Effects of irrigation:

It is commonly observed that the vegetative growth of coffee exhibits a cyclic pattern throughout the year.[3, 13, 18, 39] Such factors as climate, carbohydrate and mineral nutrition and fruit load are all intimately associated with this rhythm of growth.[9, 10] The exact interrelationship of these factors is as yet not completely understood.

This cyclic pattern is most pronounced in areas where there is a sharply defined wet and dry season. During the dry period, growth very nearly ceases, suggesting a state of dormancy. It has often been said that this "resting period" is essential for the well being of the tree. The stimulation of tree growth by irrigation during this period and the correlation of this growth[9, 12, 28, 40] with subsequently favorable tree behavior lends considerable doubt as to whether this idea is completely correct. Further investigation of this point and its relation to tree status, environmental factors and cultural practices seems highly desirable.

Growth measurements at the Scott Laboratories,

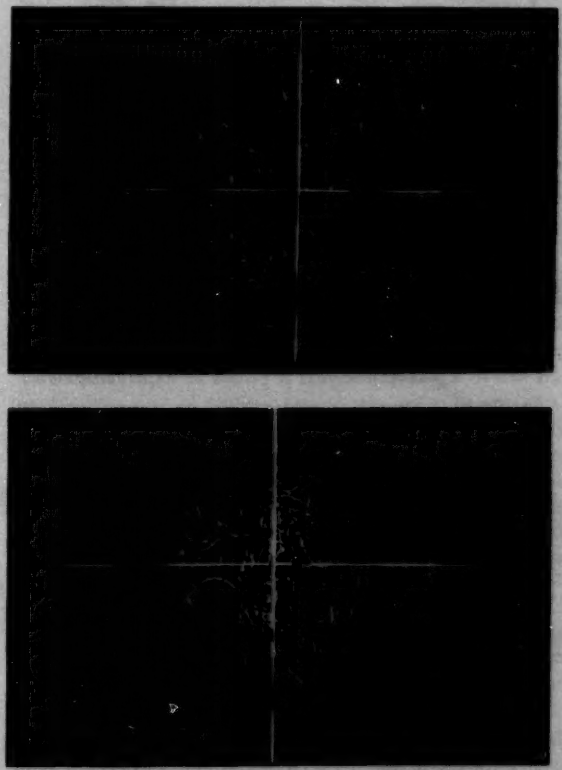
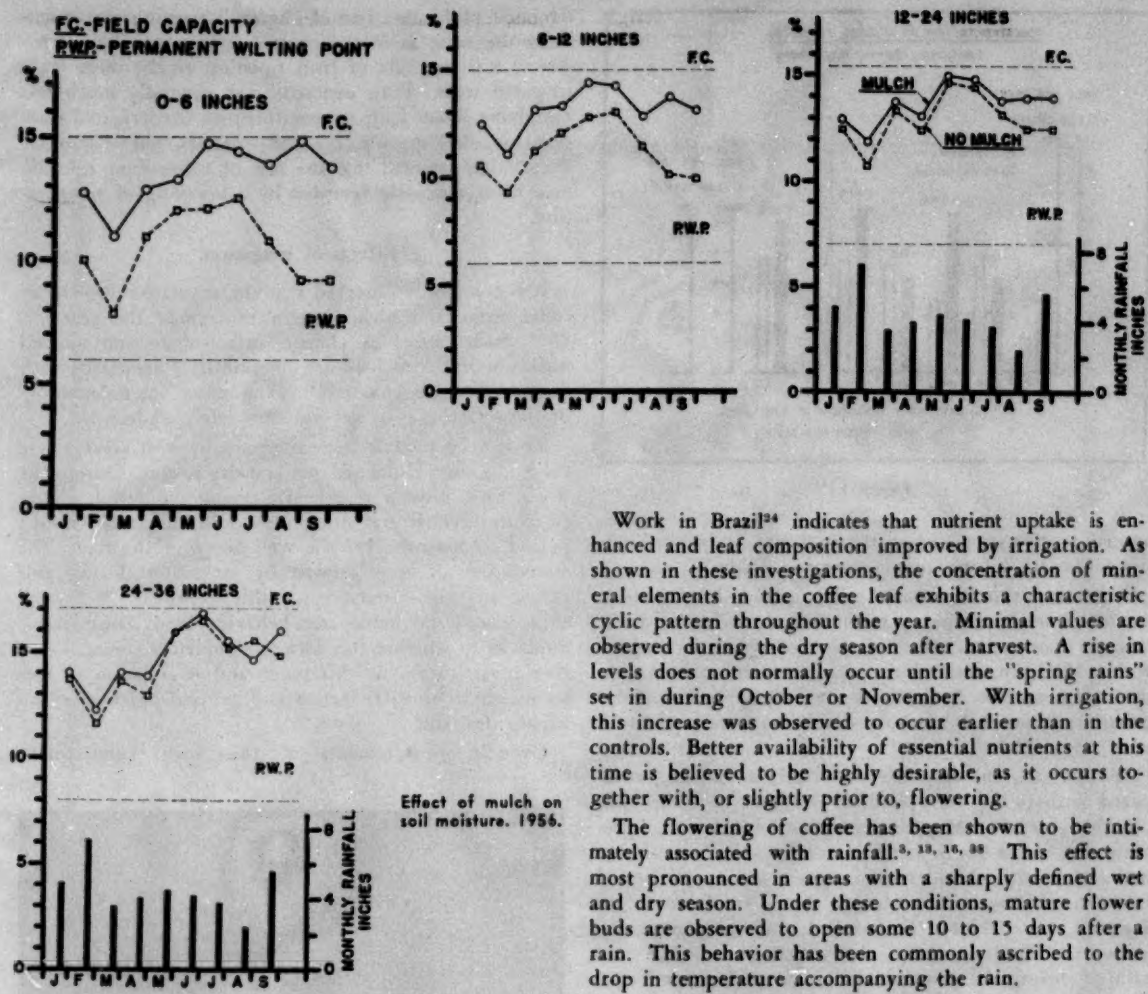


Figure 2. Irrigated (top) and unirrigated (below) trees at the end of a severe drought period. Note the much more abundant foliage on the irrigated tree.



Effect of mulch on soil moisture. 1956.

Kenya,[40] demonstrated a more vigorous and uniform growth pattern for irrigated trees. This in turn was associated with more regular flowering. Especially significant was the conclusion reached that "the basic influence in the development of a flowering is the amount of growth in a period one year previous to its development."

In Brazil,[28] growth measurements on young irrigated trees during the dry season demonstrated the following effects as compared with unirrigated controls: (1) a two-fold increase in length of laterals, most of which was due to greater internodal growth but also in part to a 20% increase in number of nodes; (2) an 80% increase in individual leaf length; and (3) a 45% increase in total leaf area. The typical improvement in foliage after several months of irrigation during the dry season is illustrated in Figure 2. The unirrigated trees show an almost complete loss in foliage. In contrast, the irrigated trees maintained an abundant leaf cover. Studies in Hawaii[9, 10] show the importance of an adequate leaf area for carbohydrate synthesis, especially at flowering. Mayne[27] has also shown that there is a close relationship between number of flower buds present at blossom time and the number of leaves present on the same branches.

Work in Brazil[24] indicates that nutrient uptake is enhanced and leaf composition improved by irrigation. As shown in these investigations, the concentration of mineral elements in the coffee leaf exhibits a characteristic cyclic pattern throughout the year. Minimal values are observed during the dry season after harvest. A rise in levels does not normally occur until the "spring rains" set in during October or November. With irrigation, this increase was observed to occur earlier than in the controls. Better availability of essential nutrients at this time is believed to be highly desirable, as it occurs together with, or slightly prior to, flowering.

The flowering of coffee has been shown to be intimately associated with rainfall.[5, 13, 16, 38] This effect is most pronounced in areas with a sharply defined wet and dry season. Under these conditions, mature flower buds are observed to open some 10 to 15 days after a rain. This behavior has been commonly ascribed to the drop in temperature accompanying the rain.

In an investigation conducted under controlled conditions at the Earhart Plant Laboratory,[31, 33] a study was made of the factors causing coffee flowering. When young coffee trees with mature flower buds were shifted from a 30°/24° C. to a 23°/17° C. (day and night temperature) environment, flowering occurred 12 days later. Of equal significance was the observation that an even more profuse flowering could be stimulated when intact or cut branches with mature buds were sprayed with, or placed in, water. When immature flower buds were similarly treated, no flowering was stimulated.

Mes[31] interprets these tests to indicate that it is predominantly a water deficit in the mature buds which controls their final development to open flowers. "The positive influence of rain in breaking the dormancy of flower buds on the trees in coffee plantations is probably due to the same effect and not to a lowering of the temperature as such," she states. In these studies, positive effects on flowering were only observed when the actual flower buds or parts of the tree were wet with water, similar to the effects of an overhead irrigation. Negative results were obtained when only the roots of water-deficient trees were irrigated.

In contrast to these findings, Piringer and Borthwick[37] report a stimulation of flowering when coffee trees grow-

ing in pots were watered. Somewhat similar results have also been reported from West Africa by Porteres.[38] These conflicting observations may simply indicate differences in the relative effectiveness of the two methods of irrigation in relieving the water deficit in the buds. Under extreme drought conditions, with high transpiration, watering of the leaves and flower buds may be required to reduce the deficit to the "critical" level necessary to "trigger" flowering.

In areas where it might be feasible to employ either overhead or surface irrigation, these findings could be of considerable practical importance. Finally, there is the fascinating field of investigation which has been opened up by the work of Alvim[1] with gibberellic acid on coffee flowering. The use of this hormone to regulate coffee flowering and its effects under varying climatic, plant and cultural conditions (such as irrigation), awaits the study of coffee scientists throughout the world.

Irrigation control

Methods to determine the proper scheduling and amount of water to apply to achieve maximum benefit in coffee have not yet been thoroughly defined. Early experiments utilized rather empirical methods to determine the quantity of water to be applied.[16, 53] Irrigations were usually made to supply various preconceived totals of moisture (rainfall plus irrigation) during certain periods of the year. At Matão, Brazil,[28] experiments are underway to study tree behavior and yields when coffee trees are allowed to deplete soil moisture to various levels throughout the available range. In Kenya[19] new tests are comparing irrigation at three periods of the year using climatic data to determine water scheduling.

Measurements to determine soil moisture continuously in situ have been made in Africa, India and Brazil using plaster blocks and nylon and fiberglass units.[5, 6, 8, 34, 49] For various special studies, these methods offer certain advantages over the conventional technique of collecting soil cores with a tube or auger for oven drying. The latter method, however, is probably to be preferred for the most accurate assessment of soil moisture utilization under field conditions.

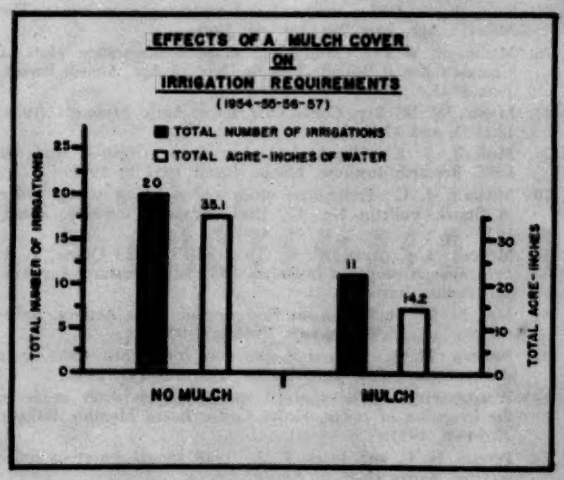


Figure 4

★ Advances in Coffee Production Technology

Better control of water supply for coffee production

Based on recent advances in the field of agricultural meteorology, the prospects of computing soil moisture depletion from meteorological data look very encouraging. The inherent simplicity of this method, its low cost as compared with conventional soil sampling methods, and applicability over wide areas recommend it for trial in coffee irrigation research. For a review of the basic principles involved and their application to irrigation problems in other crops, attention is called to the studies of Penman, Thornthwaite et al.[4, 37, 42, 46, 47, 48, 50]

Utilizing these principles, Pereira[33] reports the results of several years study relating the water use of coffee trees to open pan evaporation. Good agreement was obtained between actual moisture extraction in the root zone and values calculated from evaporation measurements. An investigation along somewhat similar lines is also being made in Brazil.[28] Moisture consumption in old and young coffee is being studied in relation to various meteorological measurements, utilizing evaporimeters, atnometers, etc.

Coffee mulching

The benefits of mulching for improving coffee yields have been reported by field experiments and practice in such widespread coffee countries as Africa, Brazil, El Salvador, Malaya and Colombia.[14, 16, 18, 20, 25, 26, 29, 35, 45, 51, 54, 55, 56] Probably the most outstanding responses have been obtained from the drier areas of Africa. With Robusta coffee in Uganda, Haarer[16] reports a threefold gain in yields for mulched plots as compared with plots receiving only chemical fertilizers. Gains as large as 100% are not uncommon in British East Africa.

Throughout most of the coffee producing areas of Kenya and Tanganyika, rainfall is the most serious factor limiting production. Not only are annual rainfall totals extremely sparse (often as low as 25 inches) as compared with other coffee producing countries throughout the world, but also extremely irregular.[15-21] Yields generally show a close relationship with rainfall and available moisture.

Under these conditions, the response to mulches has been attributed largely to their beneficial effects on soil moisture. Studies have demonstrated consistently higher soil moisture values under a mulch than with bare soil.[20, 24, 51] The mulch cover not only reduces the loss of soil moisture by evaporation but also improves infiltration. This results in better utilization of rainfall. Pereira and Jones[55] at Ruiru, Kenya, found that a nine inch rain penetrated to a depth of 4½ feet under a Napier grass mulch as against only a 1½ foot in bare soil.

Early experiments demonstrated that "pre-rain" mulches were superior to applications made at the end of the long rain period, April to June.[35] This was attributed to the greater penetration and moisture storage during the rainy period. Subsequent observations indi-

cated, however, that this may not be true after several years of mulching due to cumulative effects of the mulch applications on soil conditions.[32]

A variety of organic materials have been used in East Africa for mulching, the most commonly used being Napier (Pennisetum purpureum) and banana trash. The quantity of material required depends largely on whether the mulch is applied to all rows or only on alternate rows. Experimental data have shown no significant difference between the two methods of application.[16] Economics favor the alternate row method, in which case approximately three to five tons (oven dry weight) of material are required per acre per year. Providing a final mulch thickness of about four inches is obtained, moisture conservation effects are essentially independent of type of material and depth of cover.

Mulch responses in field experiments conducted by the IBEC Research Institute in Brazil have been reviewed by Medcalf.[29] Single year gains of as much as 100% were reported as compared with fertilized unmulched plots. Yield trends suggest that longterm differences of about 50% may be expected. Relative gains have been substantially greater with the new Mundo Novo variety than with selected strains of Bourbon Vermelho. Experiments in old trees (25-30 years) of unselected Arabica have shown no yield response after three to five years. Current experimentation involves studies on the interaction of mulching with minor element fertilization, irrigation and herbicides. Economic studies of various management systems for mulching, including "strip" plantings of grass and coffee, are also being investigated.

In these Brazilian tests, it has been found that the increase in soil moisture under mulches is most evident at shallow soil depths, from 0 to 12 inches, although it may be measurable to about three feet, see Figure 3. The effects of a mulch on soil temperatures are likewise observed to be more pronounced at shallow depths.[31] Since the root system of the older coffee trees are deeper and more extensive, these benefits may be of less relative importance than in younger trees, where most of the roots are found near the surface. This may partially explain the difference in mulch response between old and young trees. Although no yield response to mulches has yet been observed in old stands of coffee, indirect benefits in connection with irrigation have been noted, see Figure 4. As shown by these data, the conservation of soil moisture with mulches has reduced by more than half the irrigation requirement over a period of four dry seasons.

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World trade in coffee rising about 2% annually

World trade in coffee has been rising about 2% annually, according to the U. S. Department of Agriculture.

In 1958, however, world imports of coffee are expected by USDA to remain at the same level as in 1957.

Brazil exported 13,600,000 bags during the 1957/58 coffee year (July-June). This was 9% less than the year before.

Exports from Colombia for its 1957/58 year (October-September) were about 10% ahead of the previous year.

U. S. coffee imports for the year ending June 30th, 1958, amounted to 20,340,000 bags.

Of this total, about 10,000,000 bags were imported during the period January-June, 1958. Shipments from Brazil to the U. S. during this period amounted to 3,510,000 bags; from Colombia, 1,710,000 bags.

Coffee roastings in the United States during the first half of 1958 have been estimated at 10,467,000 bags (green weight). This is 2.2% more than in the same period of 1957.

Roastings for soluble coffee increased 6.6% during these periods.

the sun-hedge system of coffee growing

By WILLIAM H. COWGILL, Office of Food and Agriculture
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The nature of this article of necessity will differ from the others in this review; there does not exist as yet an extensive body of literature on which to draw, so that this means of presenting the subject is not possible. It has been thought, however, that there is sufficient current interest and future potential in this rather novel approach to coffee growing in the mild coffee areas so that the inclusion of a brief review here will not be entirely out of place, despite this lack of background research. It is the intention of this article to outline the preliminary results obtained with the system to date, not only for the purpose of describing the potential for greatly increased per-area yields, but also to point out some of the difficulties that may be encountered with its use, and to suggest certain further lines of experimentation that are still in great need before general recommendations are possible.

The idea of growing coffee in the sun was not new, of course, when the sun-hedge system was originated; many areas, such as in Brazil, East Africa and Hawaii, had been doing so since the culture of coffee was introduced. Many different spacings had been tried also, some of which approached the system in density of coffee plants per area. The "Sun-Hedge" name, however, was used by Cowgill[1] to describe the trial plantings started in Guatemala in 1945 to heighten the contrast with the usual method of culture in the area, where coffee was traditionally grown in orchards, under shade trees, and with at least 10 x 10 ft. spacing. As pointed out by Suarez de Castro and Uribe,[2] these early plantings were no more than preliminary trials incapable of yielding indisputable data. The appearance of the plants and the yield results were so striking, however, that the planting of more serious experiments was stimulated, as reported by Cordon et al,[3] Triana,[4] and Uribe.[5] Yet others are known to have been planted in several countries, in Latin America and elsewhere, though only in the past few years, and if published reports on them exist they have not come to our attention. Extension bulletins on the subject have been prepared in Cuba,[6] Panama, Ecuador and elsewhere. Sun-growing of coffee was among the subjects treated in reviews by Guiscafre[7] and Sylvain.[8]

Of perhaps even greater interest is the fact that the idea has stimulated trials by private growers in a number of countries. Suarez de Castro and Uribe[2] commented on a number of such trials in Guatemala, Mexico, El Salvador and Costa Rica. They mentioned over 2,000 hectares planted "on the contour and without shade" in one area of Mexico, and it has been estimated that an even larger area has been planted privately in Guatemala. In our travels, we have seen or have heard on good authority of additional trials in Bolivia, Ecuador, Peru, Panama, Nicaragua, Cuba, The Philippines and Ethiopia. Doubtless other trials will be planted; Hopp[9] reporting on the results of trial plantings at Chinchiná has suggested that Colombia could profitably consider demonstrating the method on some 50,000 hectares of small farms.

Briefly, the Sun-Hedge system consists of growing coffee in close-spaced contour hedges, without overhead shade trees but with alternating strips of low cover crops, similar to the alternate strip-crop method used with some other crops in soil conservation programs. On gentle slopes (up to 15%) and where wheeled machinery is to be used for some of the field operations, three-row hedges have been recommended, the coffee plants spaced about 3 ft. apart both in the rows and between rows, the entire hedge alternated with cover crop strips of equal width. On steeper slopes (up to 30%), or also on the gentler slopes where it is not planned to use wheeled machinery, two-row hedges have been recommended with the same spacing of coffee and again with one-half of the land surface in cover crops. On steep sites (over 30% slopes), single-row hedges covering only about one-third of the surface area have been recommended. It is common knowledge that coffee plants usually produce heavier and more trouble-free yields in their first 5 to 15 years; a basic hypothesis of the new system was to take fullest advantage of this fact, with the intention of rotating the crops, i.e., planting new coffee in the space occupied during the first phase by cover crops and vice versa. The age at which the coffee should be replaced was expected to vary with local environmental conditions; at the Chocolá station in Guatemala it was originally estimated that this would be at about 15-20 years.

The most outstanding advantage of the use of the system has been the yields obtained. The literature cited above and other reports vary in detail, but agree rather remarkably that compared with the coffee grown as usual under shade, yields have been earlier by a year or more, and have been not just somewhat greater, but several times greater. The small, early Guatemala plots for years yielded at the rate of 5 to 8 times the average for shade coffee in the area; some of the plots yielded at the rate of over 4,000 lbs. of dry clean coffee per acre in an area where the average for the usual shaded coffee was

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350 to 400 lbs./acre. Suarez de Castro and Uribe[2] noted a sun-planting in Guatemala with a 4-year average production of about 20 cargas per manzana on a farm producing 5 cargas per manzana under shade; they also noted an experimental field in Mexico which averaged over 18 cargas for the first three yields where shaded coffee averaged 3½ cargas. Uribe[5] reports that all four treatments in a sun-coffee experiment at Chinchiná gave much better yields than the average for the best coffee areas of the country; in their best treatment they obtained as much parchment coffee in four crops as was usually obtained in 20 years from shaded coffee.

While higher yields are the greatest advantage of the new system, and in themselves sufficient to warrant trial of the method, other noteworthy advantages also are possible. With the hedges planted on the contour and with cover crops established in the intervening strips, soil erosion can be most effectively controlled. Using a low-growing, non-twining perennial legume as the cover crop, once this and the coffee are well-established, the need for weeding should be considerably lessened or almost eliminated. On the two-row and one-row hedges, particularly, pruning of the coffee can be kept at a minimum or eliminated. The 6-10% per year replanting necessary to maintain the usual shaded orchards is unnecessary in the Sun-Hedge system. As yields are concentrated in smaller areas, harvesting is greatly facilitated. The alternate-strip contour arrangement also facilitates access for any necessary pest and disease control work.

Though the Sun-Hedge system offers considerable potential for intensifying coffee production, it will by no means be easily adapted to all environments, and its use in any situation must be accompanied by increased attention to and intensification of the technology of cultural methods. When it is possible to obtain 20 years of yields in only 4 years, it is obvious that physiological and other events may be occurring at a greatly accelerated rate and will require closer supervision and prompter attention when necessary. In the most favored of locations, it may be possible to reap the additional yields with little change in the tempo of management. As less-optimum environments are encountered, however, it can be expected that the intensive culture will require greater increases in management capabilities and resources than the traditional extensive culture.

One of the most apparent increased requirements is for nutrition. Whereas much of the shaded commercial coffee is fertilized haphazardly, if at all, and often gives a most variable and sometimes negative response, in most instances notable benefits have been achieved with fertilizers on Sun-Hedge coffee, and in some cases they have appeared almost essential to satisfactory development. This is true not only of the so-called major elements, from which such outstanding responses are being obtained in Hawaii, but also of the minor elements. One particularly striking instance was seen in Guatemala, where surrounding shaded coffee had existed for years showing only moderate symptoms of magnesium deficiency, but after only two heavy early crops the Sun-Hedges exhibited advanced stages of deficiency. Obviously, because of the accelerated rate of development, the Sun-Hedge coffee grower will need to be unusually alert to the possibility of inadequate nutrition, skilled in the diagnosis of its cause, and ready and able to apply prompt remedial or preventive measures.

Another apparent need is for effective disease and insect control. Not only are the plants more concentrated in this system, which can facilitate disease and insect build-up and spread, they also are in a changed environment with reference to light, temperature, humidity and air-movement. In this situation, not only will a difference in rapidity of attack be expected, but also the make-up of the disease and insect complex probably will be different. For example, "ojo de gallo" and thread blight probably will be less severe under the higher-light, lower-humidity conditions of sun-coffee, whereas these conditions may favor extraordinary development of die-back diseases and leaf-miners.

Experience and experimentation alone can solve these and many other remaining problems of growing coffee in Sun-Hedges. Some of these other problems concern optimum spacing, for example. The recommendations for the 3, 2 or 1-row hedges, as well as the spacing within the hedges, were made from purely hypothetical reasoning rather than on the basis of solid experience. Already to be noted is a preference for the 2-row hedge, and doubtless further modifications of the recommendations in this respect will be forthcoming. Another factor needing study is that of the best variety for the purpose. The early work has found Bourbon more adapted than the Typica variety, but it is entirely likely, even probable, that other varieties will be found more suitable for certain locations, and it seems particularly likely that some of the newer semi-dwarf types, such as "Caturra," "Villalobos," "Pache" and the like, may prove outstandingly successful for this new system.

There is need for a whole series of experiments and trials on the best methods for planting and establishing the Sun-Hedge. There is urgent need for even preliminary information on the most efficient method of converting existing shaded orchards to intensive sun hedges, so far only being studied, to my knowledge, and that in a small way, by White[10] in Nicaragua. White is finding complete shade removal and interplanting the hedges among existing coffee the preferred method under his conditions, though much more extensive trials are needed.

It seems apparent that mild-coffee growers are going to be ever more forced by economic and social pressures toward increased efficiency of production, and the potential of some modification of the Sun-Hedge idea will not be overlooked. In fact, there is every indication that increased attention will be focussed in this direction. None of the problems so far encountered seem insur-

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mountable or incapable of being solved by experience, and as the answers are accumulated and word of the several-fold yield increases spreads, we may see even some of the more conservative of the traditionally conservative coffee growers removing the shade and converting their best acres to coffee hedges.

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Says coffee quality from vending machines depends on knowledge of beverage factors

The coffee beverage dispensed by an automatic vending machine is only as good as man cares to make it, Dr. Earl Lockhart, scientific director for The Coffee Brewing Institute, told a Coffee Clinic session at the National Automatic Merchandising Association at the Sheraton-Jefferson Hotel, St. Louis.

"Machines can be built to make coffee," Dr. Lockhart said, "but the men who build the machines and the men who service them have to make the decisions that determine whether the coffee is good or bad. To make any decisions at all, manufacturers and operators must know something about judging the quality of coffee and the factors that can affect coffee quality. Without this knowledge there is no basis for making any decision or for preparing high quality coffee."

Dr. Lockhart went on to stress the factors that govern and determine coffee beverage quality, citing the importance of formula, timing, temperature, cleanliness and freshness.

To point up his remarks, he called on John J. Jurgens, CBI field research director, and Warren Schmidt, midwestern field representative, to perform a conventional brewing demonstration. Each step of the presentation underscored the importance of the factors mentioned by Dr. Lockhart. The CBI representatives demonstrated the use of the hydrometer in beverage evaluation by testing the various brews prepared.

At the end of the session, the audience broke up into a series of workshop groups which discussed various aspects of merchandising promotion and preparation of coffee.

Fig. 1—A Caterpillar clearing unit of "Section de Mecanisation Agricole de Daloa", on the border of a secondary dense forest curtain.

Fig. 2—Land entirely cleared and ditched along plant rows by means of a D.4 Caterpillar pulling a crowder-wigs subsoiler on a Killifer chassis.

the mechanization of cultural operations

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Chef de la Région Agricole Ouest
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When considering application of mechanical means to coffee cultivation in Africa, south of the Sahara, one should realize that it applies exclusively to savannah areas.

In great productive areas of sub-equatorial forest land—Ivory Coast, French Equatorial Africa, Cameroon, Guinea—one notes that mechanical appliances give way to human toil. Clearing becomes both manual and selective, thus excluding any hope of future mechanized cultivation.

In such a forest environment, total undergrowth clearing as a preface to cultural operations, is carried out only on European-owned estates, where in the absence of any other opportunity, old coffee plantations, destroyed by tracheomycosis, are being rehabilitated. Earlier clearing now facilitates undergrowth clearing at low cost.

However, apart from the cases in point, particularly European-owned land on the Ivory Coast (Gagnoa, Lahou and Abidjan Districts), reclamation of forest land for coffee planting has hardly resorted to mechanization.

Such a cautious attitude is due to following economic and technical factors:

1. Size of tree species. This requires powerful mechanical means, while exposing men and material to constant danger, and involving costs too heavy for profits likely from coffee planting.

2. Intense soil disturbance. This is brought about by mechanized clearing of undergrowth, clearing of fellings, etc., together with excavations resulting from uprooting big species. Such precultural degradations, bad as they may be, are amplified by inevitable losses in fertility resulting from the action of atmospheric elements on denuded soil.

The cautious methods applied until now are the outcome of such apprehensions. Whenever a decision is made to fell full-grown trees, axe and saw are used, but the stump is left untouched. However, if the stump is to be removed, preference is given to semi-mechanical appliances (winches) or non-mechanical means (dynamite, bark-ringing, poisoning) but never to plain manual methods, though they may be much quicker and not always costlier.

As regards tractors, their contribution remains incidental —wind-rowing and heaping of fellings.

Curiously enough, prejudices against full use of tractor potential is not entirely founded on experience. In fact, the use of full track vehicles for full clearing of dense forest areas, to establish mechanization of the various operations in coffee cultivation, remains a poorly explored technical field. Until recently, it had not given rise to any appropriate investigations, at least, in Africa south of the Sahara.

For this reason, the author has thought it advisable to carry out the present investigations, while stressing certain unsolved basic problems:

1. Is a judicious combination of manual work with tractor power sufficient to root out and log away existing forest species?

2. Is a mixed clearing method more economical than

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Fig. 3—A single disk ridger mounted on a John Deere 5 BX chassis, pulled by a D.4 Caterpillar.

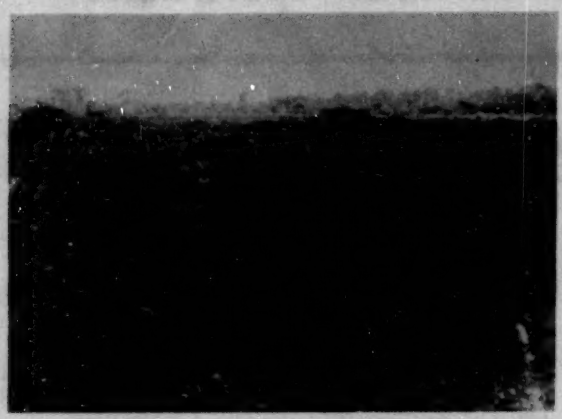

Fig. 4—The ridger simultaneously earths up two rows of coffee trees 20 cm. from their base.

Fig. 5—Robusta INEAC coffee trees. Transplanted 2½ years earlier on mechanized open land (2.50 x 4m). Low single stem pruning: 1m.60.

hand labor alone, or hand labor with small semi-mechanical means? Will it pay, if considered in the light of the economics of future coffee farming? What are the conditions required?

a. *Agrological:* Provided fertility, stability and depth of soil are admittedly appropriate for mechanization. Should one prefer dense forest land, which as a rule amply meets this treble objective? Or should one incline toward old tree fallow land, more exposed to erosion, not so adequate for coffee planting, but more accessible to mechanical implements?

b. *Mechanical and technical:* Should consideration be given to an absolute minimum of mechanical potential needed to meet the usual requirements of forest clearing? Or to super-heavy tractors, in the first stage of heavy reclamation work? Or to an ideal mechanized clearing unit? Or eventually to mechanized and/or mixed instruments and methods least harmful to the arable layer?

3. Assuming that such complete clearing is designed to open the way to optimum mechanization of cultural operations, what kind of an economy does it imply? And what would be adequate methods?

4. Since mechanization of coffee farming appears to be profitable when practiced on a commercial scale, would it be compatible with the agrarian system and customary methods applied by African coffee growers? What would be the modifications in land tenure, cultural and social customs liable to follow adaptation of this modern technique to customary African coffee cultivation?

These factors explain why the author has thought it wise to consider the problem from the technical, economic and social point of view, the latter receiving primary attention.

As seen from an agrarian and ethnical angle, the Daloa region—where the experiments referred to have been performed—is a perfect sampling of Ivory Coast coffee cultivation. It is laid out in dense forest areas by black Eburneo-Liberian farmers, whose traditions are deeply marked by the conservative aspect of the equatorial forest itself.

Seen from an agro-climatic angle, this region belongs to one of the two great coffee belts of the Ivory Coast, i.e. the inland zone, favored with flat crystalline and comparatively fertile soils, but hampered by excessive climatic fluctuations. This contrasts with the coastal zone, which has optimum rainfall and moisture, but poor and shallow sandy soils.

Mean annual rainfall attains 1,450 mm. on 113 days. However, rainfall distribution is either uselessly over-abundant during the winter, or so scarce as to reach absolute aridity (60 to 80 anhydrous days) during the dry spell.

Typical secondary patches, usually cleared, number from 700 to 1,000 trees per hectare, of which 40 to 80 present a ground-level diameter above 0.80; 130 to 170 above 0.40; and 530 to 750 small trees with diameter from 0.10 to 0.40.

Material and equipment available were the following: a repair shop to be credited with many achievements; a caterpillar clearing unit equipped with two D.7's with automatic lifting devices and, two D.4's with hydraulic lifting devices, plus bulldozers, rootrakes, clearing-dozers, stumpers and hyster winches (based on a theoretical operation of 5,000 hours/meter, the daily costs of these implements and tools amount respectively to 15,000 and 8,500 Francs); light crawler and wheel-tractors with sets of attachments.

The tests, under survey since 1952, cover: 500 hectares of cleared land, with 320 hectares planted, of which 150 to 200 hectares are in continuous cultivation.

The whole area is divided into several dozen plots distributed over 1,600 square kilometers.

1. CLEARING OPERATIONS

Set-up of mechanical unit

No limit can be assigned to the power of heavy tractors. Whatever the nature of the vegetation to be cleared, a higher cost per hour invariably finds compensation in higher efficiency. A case in point shows that exhaustive clearing effected with a D.4 ran from 9% to 12% higher than the same clearing carried out with a D.7.

If most heavy logging is to be carried out by mechanical means without having to saw felled timber, and if the major part of the highest trees is to be felled (up to 1 m basal) with fewest possible risks, the operational unit should be:

—*optimum:* one 130-160 hp tractor with drawbar and two 80 hp tractors with drawbar. Anticipated output: 2 hectares per day;

—*minimum:* three 80-100 hp tractors, with drawbar. Actual output: 1.2 to 1.4 hectares per day.

Total clearing

The object of this operation is to clear a given area from all existing vegetation, including stumps, thus opening the way to fully mechanized operations. This, however, gives rise to a twofold danger:

1. Overturning of the tillable layer and disagregation brought about by uprooting and scraping of the surface with clearing implements.

2. Total removal of green cover, exposing denuded soil, already greatly disturbed, to degrading meteorlogic elements, rapidly giving way to unbalanced edaphic and biotic conditions.

In extremely severe cases, over-mechanization has resulted in an immediate withering of coffee trees planted on such degraded land.

But both dangers may be avoided, on the one hand, by limiting damage brought about by clearing operations; on the other hand, by rational application of corrective methods to damage inevitably caused by these operations, in spite of all precautions.

How can undesirable effects of mechanized clearing be limited, if not totally avoided?

1. By strict limitation of implements most harmful to arable land, i.e., *bulldozers*. They have no substitute for undergrowth clearing and quick removal of middle-size trees, yet they must be used with care. Avoid all heapings and trenches around trees to be logged. Avoid all destructive planning around elevations and holes. Avoid scraping of the humus layer, especially when weeding low undergrowth.

See that remnants are removed with less aggressive mounted implements (rootrakes and clearing-dozers) which, though raking, let the smaller elements filter through.

2. But such removal should be reserved exclusively to non-combustible ligneous remnants. Leaves and twigs, representing an important fertilizing potential, should be swathed and spread on the spot.

3. Given the absence of immediate operating "xylocides," giant stumps resisting mechanical means should be extirpated by hand. In order to restrict soil disturbance, cut roots at their neck whenever possible, thus saving essential parts of radicular bundles.

4. Termite hills are always scraped away at soil level, but care should be taken not to resort to "esthetic" planning. In so far as ground level variations are not deemed likely to become a hinderance to future tractor maintenance work, it is recommended they be left as is, rather than to sterilize the soil for the sake of planing.

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The mechanization of cultural operations

Successive stages of semi-mechanized clearing

1. Hand clearing

This operation consists in total or partial uprooting, with axe and hoe, of giant trees resisting bulldozer action.

It is generally performed on any tree whose base diameter is over one meter, and it requires, in good weather conditions (beginning of rainy season), 100 man/days work for the largest specimens e.g.: *Ceiba pentandra* or *Chlorophora* excelsa, 40 to 50 meters high, and 3 to 4 meters diameter at ground level.

Whenever the coffee plantation is to be established immediately after clearing, manual uprooting of the whole tree remains the golden method, together with explosives, although the latter's disturbance of the surface layer is just as heavy, at times. Ringing, chemical or hormonal poisoning, and incineration give but long-delayed results.

Such manual clearing may require 20 to 30 man/days per hectare of second growth, or 60 to 150 man/days per hectare of second growth, or 60 to 150 man/days per hectare of semi-dense forest land.

2. Mechanized clearing

Clearing and burning of undergrowth: Bulldozers are used for the clearing of this barely lignified vegetation, which burns or decomposes with facility. Remnants are swathed with a rootrake, dried (a fortnight, in adequate weather), burned on the spot, and strewn on the ground.

Bulldozer, treedozer or winch felling and removal of middle height, easily rooted, arborescent species:

Destruction of small mounds: 15 to 30 termitaries with Bellicositermes, Mowl galleries and mounds per hectare. Planning done with angle-dozer.

Excavations: Only important and steep holes are filled. Any ground-level variations not liable to interfere with future operations of cultivation implements are left untouched.

Stumps: Of concern here are those which have remained after initial felling; often very old, of primary forest species. Their resistance to removal depends on their state and on the grip available for the tools. When of gigantic size they have to be removed by hand and then burned; incombustible remnants are extirpated by means of a stumper or explosives.

Logging of hand extirpated giant trees: This is done only after sawing, if any, and when the felling area has been cleared of all other obstacles.

Felling and removal of trees partially unearthed by hand and dead: Medium size trees, still standing, are dealt with

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The mechanization of cultural operations

Cultural operations	COST PER HECTARE					
	maximum		*minimum*		*mean*	
	Days	*Cost*	*Days*	*Cost*	*Days*	*Cost*
MANUAL						
Pre-clearing	150	30,000 Fr	10	2,000 Fr	30	6,000 Fr
Logging of smaller fellings	10	2,000 Fr	5	1,000 Fr	5	1,000 Fr
		32,000 Fr				
MACHINE						
D.7=15,000 Fr per day	4	60,000 Fr	1½	22,500 Fr	2½	37,500 Fr
		92,000 Fr		25,500 Fr		44,500 Fr

by the stumper, in order to extract some of big roots, then by bulldozer, and, if stubborn, by winch. Dead wood originates from lightning struck or burned trees. They must be tackled carefully, for they break up easily.

Light cleaning and planing, in order to crush remnants on field borders.

Duration of clearing

The best time for clearing operations is determined by following major climatic and cultural factors:

Rainfall sufficient to facilitate tree extraction.

Humidity allowing incineration of small remnants.

The period between clearing and establishment of a plantation should be sufficiently long to allow for breaking up of land, hole-boring and planting of provisional shade species, yet not too long, avoiding extended exposure of denuded soil to climatic influence.

A short survey shows that the best time is March-April. In regard to the clearing period itself, one may deem it to be eight months (September-April) i.e., 240 days, from which 100 may be allocated for maintenance work and stoppages because of breakdowns or rainfall, thus leaving 140 actual work days for each clearing campaign.

Performance

Daily: mean, in terms of meter/hours, with D.7, calculation based on clearing of 320 hectares: 14 meter/hours, per hectare, i.e. 2½ tractor/days, or, 40 acres per tractor/days. Annual: 56 hectares per tractor D.7 for a period of 140 actual work/days, provided two tractors are operating.

Economic advantages of mechanization

Comparison of manual and mechanized methods is purely speculative, as substitution of tractors by manual work can only be conceived for one or two cases in point, i.e., felling and rooting of giant trees and clearing of smaller fellings.

Other tasks could eventually be carried out by hand, but at prohibitive costs. This would include felling of medium size species, clearing of undergrowth, removal of stumps, and planning. Heavy logging is necessarily left to machines.

Exploitations off normal standards obviously present higher discrepancies. If hand clearing of second growth is twice as expensive as semi-mechanized, the discrepancy increases when it applies to full grown trees, hand labor being three to four times costlier than tractor clearing with an adequate team.

On the other hand, when one has to deal with old treeless fallow land instead of forest land, labor's priority becomes obvious. Such secondary growth is cleared by hand, within 100-130 days/hectare, i.e., in terms of cost, 20-26,000 Francs. To keep step with such costs, mechanized clearing should be entrusted to medium powdered tractors (6-8 meter/hours-D7/hectare), with preference to lighter tractors—TD.6 or D.2 type—whose costs would be twice those of hand labor.

Selective clearing

This technique is meant to mechanize clearing operations, while traditional cultural practices concerning coffee are being respected to maintain highest tree cover, proto-culture and fruit yielding species (KOLA-ELOEIS, etc.), and to achieve association of coffee/food crops.

Obviously, use of tractors for undergrowth clearing and felling of medium size trees is thus limited.

Mechanized maintenance is out of question.

In a great forest, such partial clearing becomes comparatively much harder, more dangerous and more costly than than total clearing. It requires 3 to 4 days D.7/hectare for a partial task.

Economic reasons are not, in any way, responsible for its application; rather, compliance with African cultural customs with reference to coffee-growing.

2. SOIL PREPARATION—HOLE-BORING

Both holing and sub-soiling are mechanized and are considered together, the latter being all the more necessary since it is applied after a clearing operation which has done damage.

Ditching is limited to plant rows and is carried out by a D.4, with a John Deere Killefer attachment fitted with a crowder-wigs subsoiler or a ditching blade.

According to the number of times—one or two—the machine has to pass over the land, it requires 3½ to 9

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The mechanization of cultural operations

hours, D.7/hectare, and has proved to be particularly well adapted to narrow spacini (1.50 x 4 meters) and yet not necessarily costlier than routine hand holing (6,000 francs/hectare for the same number of plants, i.e., 1675). Furthermore, it allows for ploughing of a much larger surface and *requires no land marks,* as planting can be made in the ditches, provided a plain marked tape is available.

Achieving simultaneous protection against soil erosion, ploughing and continuous holing seems preferable to *general subsoiling,* which, to be efficient, requires a D.7, and costs, together with subsequent manual holing. 25,000 Francs per hectare, as opposed to 5,000; and 12,000 Francs for the above mentioned ditching.

Pre-cultural root removal by means of a stumper and clearing run to very high costs, and can only aggravate degradation caused by mechanical clearing when applied to cultivation of widely spaced trees, which do not require, initially, a fully reclaimed soil.

Occasional holding with a portable, motor driven holer has, in the most favorable circumstances, run twice as high as hand labor.

At a rate of one thousand Robusta INEAC trees, per hectare, (2m, 50 x 4m) planted on appropriate aborescent, mechanically cleared and subsoiled land, the cost is 61,000 Francs.

If it were to be carried out by hand, within the same flora environment, the cost would also amount to 61,000 Francs.

On the other hand, given a low vegetation, mechanization loses its economic priority, and one hectare planted after 100% hand clearing costs no more than 40,000 to 50,000 Francs.

Cultural operations

Within local eco-climatic environment, these operations should be carried out with due moderation, whether referring to:

Machines and implements: including two light disk tillings, handling cover-crops with less erosive implements, such as disk ridgers, scarifiers, rotavators and rotary cutters.

Method: including accrued strip-weeding in the rows: 4 to 6 hand-hoeings and 2 to 3 ridgings every year, during the dry spell.

Limitations of mechanized operations in inter-rows to keep in mind: during dry spell, nothing but scarifying; during heaviest rainfalls, weeding with rotary-cutter; in between, undergrowth clearing with rotavator or a roller-cutter.

A judicious conjunction of mowing and hoeing inhibits development of adventive and competitive gramineae and yet provides enough grass to protect the ubiquitous flora principally constituted by *Ageratum* conyzoides.

From the sixth year on, the usual inter-row spacing—4 meters—limits mechanized maintenance work. From this period on, one may grow a leguminous cover between the rows, or eventually mulching plants such as Flemingia, Leucaena glauca or Tithonia, kept within bounds with a roller-cutter and mowed by means of a rotary-cutter.

The author believes that tractors used for maintenance operations should, in most instances, be crawlers with a drawbar power of 30-40 hp, and not on wheels. Such tractors can be used both for heavy cultural operations or light clearing. On uneven reclamation soil, they show greater stability and are more economical, although operation cost per hour remains higher.

Except for tasks too heavy for men, on work both men and/or amongst other works common to labor, machines can do, the latter (even in conjunction with manual strip-weeding) has operational costs amounting to 20,000 Fr per hectare/year, while exclusively manual work would amount to 40,000 Fr for the same area.

Furthermore, the path to phyto-sanitary treatments applied with motors, by land or by air, remains to be opened.

CONCLUSIONS

From an economic standpoint, it is appropriate to admit that optimum mechanization of clearing and ensuing pre-cultural operations achieves a gain of more than 60% before planting begins. Mechanized maintenance rendered possible by such complete reclamation saves at least 50% of cultivation costs.

From a technical standpoint, why deny that mechanization puts the tillable layer to a severe test. But if from the beginning of clearing the above-mentioned precautions are observed, degradation is corrected in pre-cultural breaking up of land; mechanization is only applied during the period least favorable to erosion, and associated with an intensive strip weeding actual damaging effects may be avoided.

Soil analysis carried out two years after clearing and 18 months after planting in coffee plantations established in secondary dense forest, after rough handling and heaviest possible use of tractors, followed by systematic mechanization of operations during one year, have revealed a loss of fine nutrients, N, P, and of exchangeable bases hardly more apparent than that of control (indigenous coffee plantations of same age and nearby non-farmed forest land). Up to date, no trace of erosion has been recorded.

Provided paramount agrological and cultural conditions are available, i.e., newly reclaimed and fertile land; adequate plant material, correctly planted; provisional shade, pruning to shape, strict plant protection measures, organic and non-organic fertilization insofar as the preceeding methods apply to intensified coffee cultivation, success will be assured.

However, if one refers to their compatibility with African agrarian customs, one may say that under the present circumstances, such success remains the privilege of a few black, progressive and well-to-do farmers, cultivating adequate soils with appropriate financial means and technical training.

Nevertheless, even customary growers reap, though indirectly, some benefit from the vicinity of machine cultivated plots, because even if they cannot afford motorization, some of the cultural practices should act as an inspiration to them.

soil conservation on coffee plantations

By FERNANDO SUAREZ DE CASTRO, Federacion Nacional de Cafeteros
Bogota, Colombia

1. Introduction

Coffee is cultivated in a wide zone located around the equator between the tropics of Cancer and Capricorn.

It is grown under quite variable conditions of soil, rainfall and topography, and shows a great variety of cultivation systems.

For the study of erosion and soil conservation, it is necessary to distinguish between coffee plantations grown in the presence of big trees shading the coffee trees, and plantations grown without any shade trees.

The second system is the most common, because it is used in Brazil, the biggest producer of coffee in the world, and in some African regions—like Kenya and Tanganyika.

The first system, cultivation under shade trees, is applied by the other coffee producing countries of America—Colombia, El Salvador, Guatemala etc.—and in various African regions—Ethiopia, Belgian Congo, Angola, etc.

2. Experimental studies

Experimental studies in erosion and soil conservation have been carried out principally in Colombia (Centro Nal. de Investigaciones de Café, of Chinchiná), and Brazil (Instituto Agronómico, of Campinas) and on a much smaller scale in El Salvador (Centro Nal. de Agronomía), Puerto Rico (University Experiment Station), Tanganyika (Lyamungu Experiment Station), and Kenya (Jacaranda-Experiment Station).

3. Loss of soil and water on coffee plantations with and without shade trees

3a. *Plantations without shade trees:* Marques, Grohmann et al.[4] present comparative figures on loss of soil and water in forests, on grassland, on coffee plantations without shade trees, and on cotton fields.

The accompanying table shows a resumé of results obtained in three representative soil types in a zone with 1,300 mm. of annual rainfall.

3b. *Coffee plantations with shade trees:* Suárez de Castro and Rodríquez[6] present results of five years of experimentation, showing the following annual average of soil and water loss.

These results, obtained in soils on steep slopes typical of those utilized for coffee growing in Latin America, show

Table 1—Soil and water loss in coffee plantations without shade trees, and in other crops (annual average)

Crops	Eroded Soil In Tons Per Hectarea (annual average)	Water Loss % of Rainfall
Forests	0.002	1.2
Grassland	1.0	1.4
Coffee plantation	1.9	1.6
Cottonfield	34.0	6.1

Table 2—Soil and water loss in coffee plantations with shade trees and under different types of soil management

Crops	Types Of Soil Management Eroded Soil In Tons Per Hectarea	Water Loss % of Rainfall
Woods	0.1	2.5
Grassland	6.7	18.0
Old coffee plantation	0.4	3.0
Young coffee plantation	6.5	8.2
Bare soil	312.4	60.0

that the old shaded coffee plantation under thorough cultivation loses very small quantities of soil, comparable to those eroded in forests. The young coffee plantation loses much larger amounts of soil, similar to those carried away in grassland. These differences show the important role played by the shade trees in the conservation of the soil on coffee plantations.

4. Cultural and agronomic practices with and without shade trees

All methods used to raise resistance to erosion or to reduce the forces playing a role in erosion, are called methods of soil conservation. Usually these methods are divided into cultural, agronomic and mechanical practices.

The first ones refer to modifications in the systems of cultivation; the second to the utilization of the natural vegetation; and the third to the construction of artificial

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structures made by adecuade removal of soil portions.

The cultural and agronomic practices most widely utilized in coffee plantations are: contour planting, cover crops, green manure and living barriers.

4a. *Effects of cover crops:* The effect of cover crops on soil and water loss on coffee plantations has been studied in Chinchiná (Colombia), in Campinas (Brazil) and in Lyamungu (Tanganyika). In Chinchiná, after five years of observations, the following results were found:[6]

Table 3—Effect of cover crops on soil and water loss on a young coffee plantation grown with shade trees (annual average)

Treatment	Soil Loss In Tons Per Hectarea	Run Off (Water Loss) % of Rainfall
Check	6.5	8.2
Cover crop	0.5	6.2

This result shows that the maintenance of a living soil cover between the rows of a coffee plantation greatly reduces the soil losses.

The cover crop is established, in the case of Colombia, by sowing — "Añil rastrero" (Indigophera endecaphilla). Later on, the weeks are controlled by "machete" and the areas around the coffee trees are cleaned by hand. There is also a custom of keeping some plants of the natural vegetation, eliminating only the undesirable ones.

In Brazil, Marques and his co-workers[4] obtained the following results in experiments with covercrops:

Table 4—Effects of cover crops on soil and water loss on coffee plantations grown without shade trees

Treatment	Soil Loss In Tons Per Hectarea	Run Off % of Rainfall
Check (clean cultivation)	2.16	2.30
Cover crop	0.98	1.36

In Lyamungu (Tanganyika), in a two year experiment, annual losses of 21.5 tons of soil per acre were determined in the check-plot, against 0.23 on a coffee plantation well protected by a living cover of *Dolichos hosei*.[7]

4b. *Effects of mulch:* In the coffee growing regions of Africa (especially in Kenya and Tanganyika), and in other dry zones, such as El Salvador, mulch is used instead of cover crops.

It has to be mentioned that these regions have little rainfall, and the effect of these treatments has notably increased the production of coffee.

Gilbert[1] informs us of reductions of soil loss from 28 to 8 tons per acre for a period of three years, in experiments with mulch.

In Lyamungu (Tanganyika), in a plot on a 16% slope cultivated with coffee, which during the two preceding years had suffered an erosión of 14.10 and 28.8 tons per acre, the soil loss was reduced, under mulch treatment with banana leaf, to zero.[7]

4c. *Effect of living barriers:* In relation to living barriers (rows of plants generally perennial and of dense growth, planted in contour at different distances, depending on steepness of the slope), the only figures existing were obtained in Lyamungu (Tanganyika) in a two-year experiment, using *Crotalaria spp.*:[7]

Table 5—Effect of living barriers on the control of erosion (annual average)

Treatment	Soil Loss Tons Per Acre
Check (clean cultivation)	16.6
Living barriers of *Crotalaria spp.*	3.1

Combining living barriers with a cover crop of *Dolichos hosei*, the soil losses were reduced to 0.16 tons per acre (three-year average.)

5. Mechanical practices

Mechanical practices of soil conservation applied on coffee plantations are mostly different classes of terraces and channels of interception and diversion for run-off water.

5a. *Effects of drainage terraces:* In some coffee regions of Brazil, drainage terraces are used on slight slopes with good success. Marques[3] determined in a two-year experiment the following figures of soil and water loss:

Table 6—Effects of drainage terraces on soil and water loss on coffee plantations (annual average)

Treatment	Soil Loss Tons Per Hectare	Run Off Water (Water Loss) % of Rainfall
Check	2.16	2.30
Coffee plantations on terraces	0.29	2.02

These results show a greater effect of the practice on the conservation of soil than on the conservation of water.

5b. *Effect of individual terraces:* Individual terraces are small round terraces constructed around the trees, with an inclination of 5% in a direction contrary to the inclination of the slope.[5]

This structure has been applied especially in Puerto Rico, where Telford[8] obtained losses of soil of 0.73 tons per hectarea on a coffee plantation grown under this system, in combination with a cover crop. In comparison, the check plot showed a soil loss of 11.0 tons per hectarea.

In Colombia, individual terraces have been used in combination with "cajuelas" (small rectangular holes dug between the rows). The following results were obtained over a five year period of experimentation:

Table 7—Effect of the individual terraces and the "cajuelas" on soil and water loss on coffee plantations grown under shade trees (annual average)

Treatment	Soil Loss Tons Per Hectarea	Run Off % of Rainfall
Young coffee plantation		
(a) Check	6.5	7.9
(b) With terraces and cajuelas	0.6	10.8
Old coffee plantation		
(a) Check	0.6	1.8
(b) With terraces and cajuelas	0.3	2.3

In this case, mechanical practices have notably lowered the soil loss, but have raised the loss of water. However, it has to be taken into account that these structures have a favorable influence on slowing down the intensity of run-off water, which is the critical factor of erosión.

Individual terraces have been found inconvenient in relation to cost and because of the limitation in area imposed on the development of tree roots. Their use is now limited to dry zones only.

SUMMARY

We have summarized data on the effects of different practices of soil conservation on coffee plantations. They show that cultural and agronomic practices, especially cover crops and shade trees, are very effective in the control of erosion. They are, by the way, the most economic methods, and their application is very easy. Mechanical practices are generally expensive and have to have a complementary character in a soil conservation program.

Many of the systems applied in different coffee growing regions have not been proved by experiments to be beneficial. However, their effectiveness has been proven empirically by repeated and continued use in extensive regions.

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★ **Advances in Coffee Production Technology**

chemical weed control in coffee

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There are very few, if any, coffee producing countries in the world today where chemical weedkillers are not being tested by research workers in the field, and there are a number of countries where the use of recommended chemicals to control weed growth is becoming a general practice. The tropcial and subtropical climates in which coffee flourishes are extremely conducive to rapid and luxurious weed growth, with attendant competition between weeds and the coffee tree, to the detriment of crop yields.

Weed growth competes for soil moisture often at most critical periods in the physiology of the tree, and likewise for plant nutrients, particularly nitrogen. They sometimes serve a useful purpose as a living barrier to soil erosion, where that danger exists, and they help to maintain topsoil structure in the coffee plantation, an effect which is less apparent in the presence of a shade tree cover. On the whole, however, a large measure of control is desirable in the interests of economic coffee yields, particularly where soil moisture availability is seasonal.[12, 13]

Since 1945, great strides have been made with weedkilling chemicals in coffee, and it is worth considering the special problems involved when working in this crop. The coffee tree is sensitive to many of the chemicals used in weed control, either systemically following uptake of primary or breakdown products through the root system, or following absorption through the bark and leaves; from direct contact between the spray and the aerial portion of the tree and sometimes from exposure to chemical vapors. Foliar symptoms of toxicity have been described and reported for 2,4-D materials in Arabica coffee[1, 2, 3] [see Figure 1], and in Robusta coffee.[26] It has also been reported in one case[3] that there followed a significant decrease in leaf drop (13%) four months later.

Symptons of damage from TCA[1, 6, 31] and from Dalapon[6, 7, 8, 9] which are rather similar, have also been reported, as has damage from endothal[17]. Damage from monuron has been described[1] and susceptibility to the vapor of one 2,4-D material (ethyl-butyl-propylenglycol ester) has recently been noted[4]. To obtain the best degree of weed control, it is desirable to spray the area between the lines of coffee trees completely, a practice which greatly increases the chances of damage to the tree.

FIGURE 1. Systemic 2,4-D damage to young shoots in mature Arabica coffee

Unless otherwise stated, all weights are given as pounds (avoirdupois), volumes as imperial gallons and areas in acres.

The common names for weedkilling chemicals used throughout are those adopted by the Weed Society of America and approved or recommended by the British Weed Control Council.[39, 40]

Timing the herbicide application in relation to the stage of the weed growth, the soil moisture status and the rainfall conditions is often vastly important to obtain the maximum benefits. Where there are marked wet and dry seasons and it is possible to clean the land mechanically or by hand prior to wet weather, pre-weed emergence application of herbicides may be both effective and more economical than post-weed emergence applications.

To facilitate this brief presentation of chemical weed control work in coffee, it is simpler to consider progress under three main headings, namely: (1) direct contact chemicals, producing a kill of mixed mono and dicotyledonous weeds; (2) chemicals with a more specific action against grass weeds; and (3) chemicals effective against the broad-leaved weeds. The latter two groups will contain the "hormone", "translocated" or systemic types of chemicals.

1. Contact Weedkillers

In Brazil, Forster[15] has found monuron effective for the control of *Cyperus* sp., but only at high rates of application (≅60 lbs. per acre). In Kenya, under lower rainfall conditions, (35" instead of 55") successful mixed weed control with 6 lbs. monuron per acre is reported except for *Oxygonum* spp. and some annual grasses in the genera *Sporobolus* and *Setaria*. Some adverse effects on the tree were also observed[8]. As a pre-weed emergence spray in Kenya, 4 lbs. monuron per acre successfully controlled most broadleaved weeds, and Cyperus spp., but did not control *Digitaria scalarum* or *Oxygonum atriplicifolium*. The same report states that 5 lbs. monuron per acre as a contact spray was not very successful in controlling rather mature mixed weeds.[30] Apparently results obtained in experiments elsewhere have been unsatisfactory.[31]

Perhaps the most widely used contact sprays in coffee are diesel oil emulsions fortified with either Na-PCP, PCP or dinoseb. The following mixture is recommended by Forster

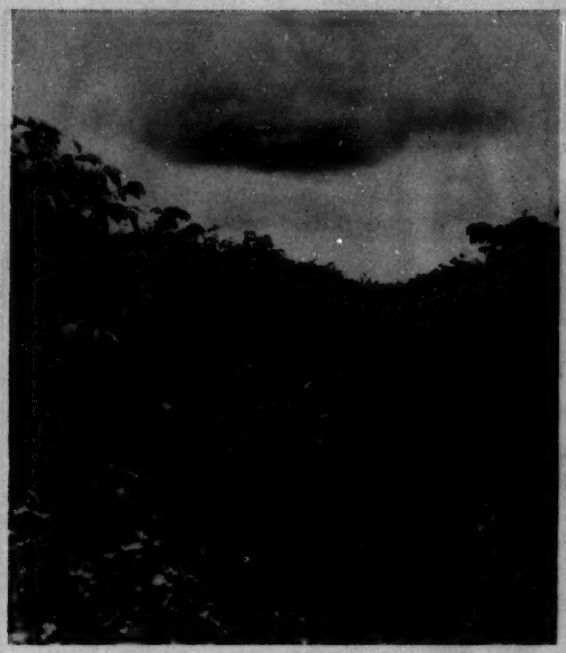

FIGURE 2

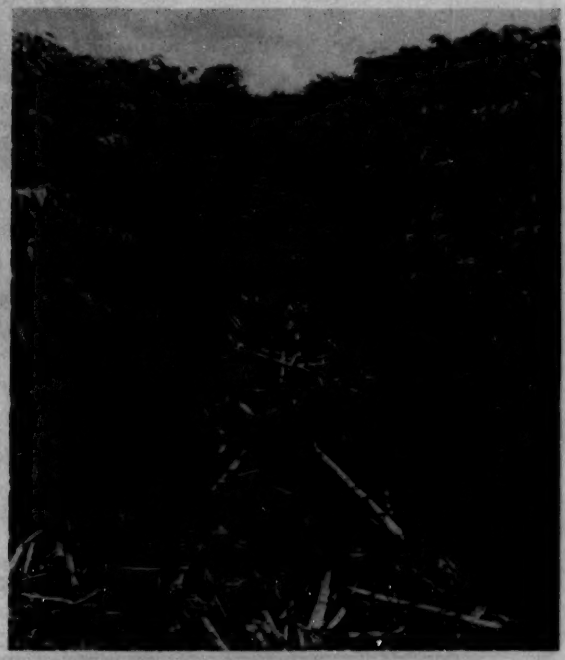

FIGURE 3

Control of mixed weed growth in mulched coffee interrows at the end of the main rains, Coffee Research Station, Kenya. Fig. 2: Check plot. Fig. 3: Two applications of PCP + 2,4-D fortified oil emulsion, at a five-week interval, during the main rains season. (Photos by Shell).

for controlling general weed growth[15]: 80% diesel or white oil, ½% dinoseb, 1½% emulsifying agent and 10-12% water. Mix 1 part of this with 4 parts of water and apply at a rate of 100 gallons per acre.

Work by the I.B.E.C. Research Institute in Brazil has shown that spraying mixed weed growth under mature coffee trees to facilitate harvesting conditions was good with activated oil emulsions consisting of Na-PCP, PCP or dinoseb in diesel oil, an emulsifier and water, e.g. 4 lbs. Na-PCP + 9½ gal. diesel oil + 150 ml. Triton B. 1956 in a total of 80 gal. water applied at rates of 16 to 80 gal. per acre, depending upon the degree of weed infestation. It is emphasized that the control is much better if the spray is applied when weeds are young and succulent, and older growth is difficult to control without the use of TCA for grasses or 2,4-D for broad-leaved weeds[16].

During 1951-52, experiments were carried out in Colombia with several chemicals for the control of mixed weeds in shaded coffee (100" rainfall), including *Alpina occidentalis, Tradescantia multiflora, Drymaria cordata, Pteridium caudatum, Piper angustifolium, Sida acuta, Bidens pilosa, Zebrina pendula* and *Commelina* spp. Only an improved dinsoeb formulation[a] at 2.6 lbs in 200 gal. of water per acre and endothal at 22½ lbs. in 100 gal. of water per acre were regularly effective, but the cost of the materials and application exceeded the cost of scythe clearing. It was also recorded that in young coffee the endothal spray resulted in slight malformation of the young leaves.[17]

In Costa Rica, post-shovelling application of fortified oil sprays containing PCP and with 2,4-D, have been recommended to the industry[18]. More recently, work by Orsenigo[15] has emphasized the value of dalapon and dinoseb oil emulsion sprays. The following formulae were applied between the coffee tree rows under Inga spp. shade trees, right up against the trunk of the coffee trees, without any apparent ill effects: (a) 2 lbs. dalapon plus 2 lbs. a.e. 2,4-D plus diesel oil 20 gal. plus water 20 gal. and an emulsifier; (b) 5 lbs. dinoseb plus 2 lbs. a.e. 2,4-D + diesel oil, 20 gal. plus water, 20 gal. and an emulsifier; and (c) dalapon, dinoseb, 2-,4-D, diesel oil, water and emulsifier at the above rates, mixed together. Low application at 16 gal. per acre was used, and each of these formulae maintained the ground free of all types of weed growth.

A considerable amount of attention has been paid to chemical weed control in Hawaii[19-20], where the rainfall averages about 70" and the coffee is now grown without shade trees. Recommendations exist for preweed emergence control with fortified oil emulsions, in freshly prepared nursery beds.[21] The formula is 1 pint of dinoseb (formulation not specified) with 5-6 gal. diesel oil, an emulsifier, and water to a volume of 44 gal.[22] A similar formula is recommended for use in mature coffee, with an alternative to dinoseb of 2 lbs. Na-PCP. It is stressed that this spray should not be applied against the trunk of the tree.[23]

From India, it has been reported that a drenching spray with a DNC formulation killed all weeds including *Cyperus rotundus, Mimosa pudica* and *Oxalis corniculata.*

A review of chemical weed control in Kenya summarized

[a] Dowspray 66, 10% improved dinoseb and 87% mineral oil.

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the results obtained to the end of 1958[14]. At that time a fortified oil emulsion containing 2½ lbs. PCP plus 1 lb. a.e. 2,4-D per acre in 40 gal. total volume had proved satisfactory for controlling mixed weed growth in mature unshaded coffee (35" rainfall) during the wet months.[9, 10, 13, 30] Crop yields were as good as plots which were hand-weeded.[30] Control of *Cyperus auricomus* and *Cyperus blysmoides* was good but no permanent control of *Digitaria scalarum* was observed. However, PCP fortified oil emulsion sprays were not recommended to the industry because of a chemical taint found in the coffee liquors and associated with the application of PCP.[10, 11]

In Tanganyika, under a rainfall of about 70", fortified oil emulsion sprays with PCP and 2,4-D similar to those used in Kenya[14] were unsuccessful in controlling *Cyperus rotundus, Kyllinga controversa* and *Panicum trichocladum*.[31, 32]

Dinoseb and PCP fortified oil emulsions are reported—from Salvador—to provide a good control of mixed weed growth in shaded coffee (70" rainfall) but with regrowth sometime after spraying[4].

More recently work has been carried out with ATA[b] (Aminotriazole) to control persistent grass weeds. Against *Cyndon dactylon*—in Brazil—it was reported[15] to have produced a complete chlorosis of the foilage and to be promising. Fron Kenya it is reported[8] that there is apparently no synergistic interaction between ATA, PCP and dalapon applied in all possible combinations for the control of grass weeds in coffee, while applications of 10-15 lbs. ATA per acre shows promise in controlling *Digitaria scalarum* in Tanganyika.[35] Some slight chlorophyll inhibition has been observed in young coffee trees following ATA sprays.[35]

2. Grass weed specific chemicals

Comparative studies with TCA and dalapon for the control of *Cynodon dactylon* in Brazil on uncut grass, showed dalapon to be superior when each was applied at 15 lbs. in 80 gal. water per acre. Lesser amounts were ineffective. Dalapon was applied once in grass growth up to 4" in height and twice, with an interval of 5 weeks, in grass between 5 in.-10 in. tall. After 7 months there had been no resprouting.[41] More recent experimental evidence[37b] has emphasized the value of dalapon for routine control of grasses in unmulched coffee, and when growing through a grass mulch. Mention is made particularly of *Cenchrus echinotus, Eleusine indica, Digitaria senguinalis* and *Brachiaria plantaginea*. Dalapon is applied at strengths between 1.4-2.2 lbs. per 20 gal. liquid to give a thorough wetting of the grasses. The inclusion of 1 lb. a.e. 2,4-D per 20 gal. with dalapon is the most promising complete weedkiller so far found.

Forster[15] has found a variable control of *Cyperus* spp. to applications of 14 lbs. dalapon per acre.

While TCA was found to eradicate *Digitaria scalarum* in Kenya[5], it would do so only at concentrations harmful to the coffee tree and more recently dalapon has become important for the eradication of this perennial weed. Dalapon plus 2,4-D has also given good mixed weed control in coffee[31] although the use of the former material for this purpose is restricted because of its high cost. Recent work has emphasized the importance of timing dalapon sprays in relation to the vegetative growth of *Digitaria scalarum* and the rainfall season. Preliminary rotary cultivation has not enhanced the degree of kill obtained[8].

In the Kivu area of the Belgian Congo[7], dalapon at a rate of approximately 5 lbs. per acre is being used to eradicate *Digitaria scalarum* in coffee. The addition of 2,4-D is sometimes made to provide control of a mixed weed stand. The inclusion of a wetting agent to supplement that already incorporated in the dalapon formulation is stated to increase the effective grass control through a better leaf wetting.

Application of 10-15 lbs. dalapon per acre is reported to control *Digitaria scalarum* in Tanganyika,[35] and in Hawaii it is recommended for the specific control of grass weeds in coffee.[24] Experimental work with dalapon is also being undertaken in Colombia.[15]

3. Broad-leaved specific weed chemicals

Dicotyledonous weed species in coffee have been controlled experimentally by 2,4-D formulations in a number of coffee growing areas.[4, 30] In Brazil it is necessary to add 2,4-D to fortified oil emulsion sprays to control mature broad-leaved weeds satisfactorily[18] and this material has been used to control weeds growing alongside coffee seedlings in the planting "cova"[15]. Forster has found the esters or sodium salt of 2,4-D to be the most effective for controlling *Cyperus* spp.[15]. In India (110" rainfall) 2,4-D is effective against *Cyperus rotundus, Striga densiflora*[20]; later work reported that MCPA and Na-2,4-D were effective against all weeds in coffee except *Mimosa pudica, Oxalis corniculata* and grasses.[27, 28, 29]

Experimental work in Puerto Rico with 2,4-D in coffee has shown that control of *Clerodendrum fragrans, Dieffenbachia sequine* and *Urera baccifera* is possible,[23, 24] and 2,4-D is recommended in the coffee industry of Hawaii for the control of broad-leaved weed species.[24] Applications must be made with care to avoid excessive exposure of the coffee tree to 2,4-D sprays.

Consistent use of 2,4-D or dalapon sprays alone gives rise to dominantly monocotyledonous or dicotyledonous weed infestations respectively, and should be avoided.

Apart from the variable natural suppression of weed growth obtained under coffee shade trees, there is another cultural practice used in unshaded coffee which markedly influences weed control in that crop, i.e., mulching. This may be with organic material or with stones, but in either case there is a control of weed growth and an effect upon the economics of chemical spraying to control weeds. In Jamaica[26] no chemical weed control is reported to be necessary as the result of mulching, which is a standard practice in the coffee; in Hawaii a mulch of coffee parchments, flat stones or grass is often placed around the trunk of the coffee tree to suppress weed growth.[22] Application of chemicals to control weeds in alternate inter-row mulched coffee in Kenya reduces the number of spray applications to the alternate mulched inter-row by ⅓-⅔ per year, depending upon the density of the mulch.

In Figure 4, results obtained by the I.B.E.C. Research Institute in Brazil[37a] are given; it will be noted that the gallonage of weedkiller necessary to provide a satisfactory

[b] Probably systemic in its action and not a contact weedkiller.

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control decreases with the two heavier rates of dry matter application.

In the Mulch 5 experiment graph, there was a 10% increase in the number of sprayings for the light mulch treatment A, compared with mulch treatment C; in the Mulch 6 experiment, the position of the point for light mulch treatment A is high, and is considered to represent a real effect following the stimulation of weed growth by a light mulch cover. In all the experiments, weed control was with a PCP fortified emulsion. More recent experimental results with dalapon sprays in mulched and un-

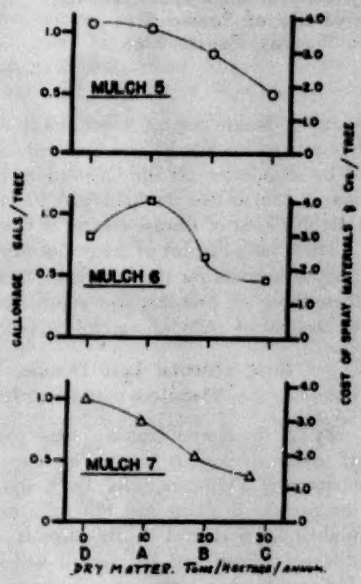

FIGURE 4. The influence of mulches on the cost of chemical weed control. (J. C. Medcalf, I.B.E.C. Research Institute, Brazil).

mulched coffee[37b] show that mulch has subtantially decreased the cost of chemical weeding, while at the same time increasing crop yields (55" rainfall).

When assessing the value of a particular treatment with a particular herbicide, final judgment should not depend entirely on the effectiveness of the weed kill, even though this may be excellent, nor on observations concerning toxicity symptoms in the tree, though these may be absent, but should also include liquor tests. The crop should be tested for its liquor quality, with particular reference to the presence of a chemical taint. Chemical taint has been recorded following the use of PCP in fortified oil sprays.[10, 11]

An obvious inference from the varied degree of success obtained in different coffee areas with the same chemicals is that climatic variations, including both total rainfall and distribution pattern, the presence of shade trees, the use of soil mulches, the soil type and the different weed species, all influence appreciably the degree of success achieved with a particular chemical.

In India[38] and in Colombia[17] hand labor has so far been the cheaper method of weed control, but elsewhere the amount of study being undertaken suggests that in addition to the control of persistent weed species, which is often more satisfactory with chemicals, general chemical weed control in coffee plantations will become more widely adopted as standard practice in the years to come.

[a] Standard degree of clean weed on fallow and no weeds through mulch.

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★ **Advances in Coffee Production Technology**

recent spraying for control of coffee diseases

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Coffee is a very widely grown crop (25). There are a number of species of the genus *Coffea* used, and of these *C. arabica* L., *C. canephora* Pierre, *C. liberica* Bull exHiern, and *C. excelsa* Chev. have long been the most important, and have among them many varieties and selections. There is probably no tropical crop that encounters more widely divergent cultural or naturally occurring ecological conditions. This has resulted in contact with many new and hitherto unknown troubles, and over 350 diseases have been reported on it. Only a few of these are controlled by spraying.

The crop grows well in first class soils, but develops in others often under marginal conditions where production can be expected as low. Transportation is also a factor. Often roads are poor and little more than trails, in some places water is the way of transport, and in some air is an accepted means of access. Growers in many cases have to plan for the use of extensive amounts of land to obtain reasonable crop returns, because of occurrence of alternate low and high production and occasional minimum crops, recurrent failures and fluctuating prices. Growing is often, but not always, characterized by absentee ownership, with plantations managed by individuals sometimes less highly trained than are used in some other modern farming operations.

All these facts have important bearing on disease control and occurrence. The differing species and varieties vary as to resistance to disease.[23, 25] Wide range in cultural practices and in ecology makes it impossible to depend on a few standardized spray systems for all disease control. A serious disease in one area may not be troublesome in another. These problems of disease control need intensive research in all the countries where they occur.

Coffee grown under marginal conditions may be attacked by parasites that are ordinarily mild or benign. However, with less vigorous coffee weak parasites may cause serious disease. Under some conditions all that may be required is improved husbandry to control some of the troubles, but in other situations it may call for more serious attention, including spraying. Where ecology is best for coffee, certain diseases may be unimportant. If plantations and fields inside them are easy of access, ready transport makes spraying less difficult and cheaper.

Lastly, spraying can be profitable only when the coffee crop is economically worth it. If methods of growing have been so neglected that production is maintained at a bare subsistence level, spraying is of only slight effect and the value of disease control is questionable. In very poor plantations, regions that become badly diseased may well deserve to be abandoned. If the horticulture of the crop has been attended to, so that the fields give harvests sufficiently large, then this kind of disease control is worth its cost.

There are a number of coffee diseases that have been given spray treatments for their control. It is believed that among these there are probably five which have received the greatest amount of study on control by spraying.

Rust, Oriental Leaf Disease, Yellow Rust; "Hemileia vastatrix," B. et Br.

By far the most feared and most potentially dangerous of all coffee diseases is Rust. This may be seen from recent reviews by d'Oliveira,[17] Raynor,[20] and Wellman.[24] Briefly, the parasite is a true rust fungus, a native of the Ethiopian highlands, is carried in air currents and by movement of diseased plants, and has spread widely throughout Africa, India and other coffee growing regions of the Orient. It was apparently first most serious on *C. arabica*, but *C. canephora* and other species are susceptible. Some types within these coffees are resistant, and varieties are being selected from them to grow where the disease occurs.

For a short while, in 1903, it reached the American tropics on diseased seedlings in Puerto Rico,[23] and was happily fully destroyed. At the present time, it is not reported from any place in the Western Hemisphere, but no one knows how long this favored condition will last. The symptoms are numerous orange yellow, powdery spots on undersides of leaves. This is followed by severe defoliation, and the extremes of decreasing productivity.

It was one of the first tree diseases controlled by sprays. Lime sulphur[a] spray was used to control it about 1869. Sometimes effects were good, but in general it gave irregular and only fair results. Almost immediately after the copper containing spray, Bordeaux mixture, had been found—for example, it was used in 1886 in Java—it was intensively studied as a control for Rust. Subsequently, for over 80 years, Bordeaux mixture and modifications of it have been used to control Rust in Africa, India, Java and many other countries of the Orient.

More recently, with better development of proprietary spray compounds containing copper, they have been improved to such an extent that many like Perenox, Blitox, Cuprokilt, Copper Sandoz and others have been increasing in popularity to supplement Bordeaux mixture. Thus far, copper in the spray seems to be the most important ingredient for the control of Rust. One or 2% sprays, at

a Names of all spray materials mentioned are collected at the end of this article, and their compositions are indicated.

the rate of 200-275 gal. per acre, are put on two or three times a year. These are just before or during the first rains or "blossom showers" that break the long dry season. Another spraying is done during the short dry season between the long and short rains. Where the disease is especially severe, another spray is applied before the short rains stop and the main dry season begins.

In the last few years, work has led to clearer understanding of spraying problems in coffee Rust control. Recently George[10] in India, indicated that under their conditions plots sprayed with Bordeaux mixture, Cupravit, and Wetcol all produced good yields of clean coffee. If unsprayed, the crops would have been not worth picking. In plots treated with the fungicide called Fungi Copper Geigy, there was about as good leaf survival as in plots sprayed with Bordeaux and Wetcol, and better than Cupravit. Yet the Fungi Copper Geigy plots only produced about half the crop the others did. He also tested certain mercury compounds, such as "Phenyl Mercury Acetate," and "Mercury Copper Oxychloride" hoping to find eradicant action, but without success.

In the same report by George, it appears that considerable attention is being given to efficiency of spray applications in India. Some of the recent work consisted of testing different nozzles, all jet types, in their delivery and coverage on an acre of coffee. These studies are still in progress, but it seems that there may be limitations in how far low gallonage can be reduced. A relatively small amount needed to cover a bush or an acre, requires a proportionately longer time for application. This is going to require more and more study by agricultural engineers.

In Africa, Drouillon[6] showed that some of the most modern spray machines could be used in coffee plantations. In this work, he tested an European type, known as "Swissatom," and an American made sprayer for tree spraying, known as "Hardie." Using these, it was found that the very small drops of fungicide, measuring 12 to 40 mu in diameter, were not fungicidally effective. Those measuring 80 to 100 were good in effect. These latter carried into the plantings to give best results in a band 6 to 30 meters wide, away from the mouth of the sprayer.

Koleroga, Black Rot, Mal de Hilacha; "Pellicularia koleroga" Cooke

The Koleroga disease is one typical of attack on trees by a certain group of fungi that are especially adapted to moist tropical conditions in areas of most countries that grow coffee. In one phase, the Koleroga on coffee grows as a coarse dark string, adhering along stems and lateral branches. In a second phase, it expands in vigorous fan-like growth to the undersides of leaves and over green fruits. The effected leaves and fruits blacken. Leaves loosen and drop from their branches, but remain attached and swing from them by fungus threads. Branch tissues collapse and are readily infected by one or more secondary parasites.

Copper containing fungicides seem to be efficacious in control of Koleroga, as was known possibly first in India.[23] It is rather well exemplified in recent works, such as those from Nicaragua,[15] Guatemala,[9] and Costa Rica.[2] In practically all cases, copper fungicides have given best results. Bianchini and Wellman[2] made a special study of Fermate, which is copper free and had shown promise under careful laboratory tests. However, when sprayed in the field, it did not hold up to the promise. Best results still remained from copper sprays.

Time of spraying is exceedingly important. If a copper spray is put on when the fungus is in its most active state, it is more readily controlled. When it is in its dark-string stage, it is not so easily killed. The fungus and spraying for it has been much studied in India. There it is appreciated[23, 25] that one or two sprayings at special intervals will result in good control that may last years. Pérez[18] showed he was able to accomplish more or less the same thing in Central America. However, where not given sufficient study, copper sprays can be put on numerous times in a year and still not yield satisfactory results.

Coffee Berry Disease, "CBD"; "Glomerella cingulata" (St.) Sp. et van Schr. var. "virulans"

Debilitated coffee cherries may be readily infected with the common *Glomerella*. However, several years ago,[10] first in East Africa and then in the Congo, there appeared a special strain of the fungus, adapted to fruit attack. Losses from it are as much as half the crop, and it is found in some of the best producing areas. It is severe on Arabica coffees, although the Blue Mountain variety seems to show some resistance. Spraying to control the trouble seemed at first almost hopeless.

The special fungus variety infects flower tissues from which are developed tremendous numbers of spores that spread to young fruits. Spores germinate rapidly, and the germ tube attaches itself to fruit surfaces entering the skin of the coffee cherry in three hours time. It penetrates flower petals in a much less time. On fruits, or berries, it causes expanding pinkish to curiously bronzed scabby spots. Its attack makes the beans within worthless.

Intensive studies were carried on with the conventional sprays for some years, with little success. It was then learned[4, 12, 13, 16, 28] that time of spraying was important, and early applications around flowering time were more effective. It had been shown that copper sprays and organic chemical compounds, including carbamates, were of no great value. With Fermate, for example, there was even an apparent increase in Glomerella. On the other hand, mercury-containing sprays gave more hope. Spraying early with mercury compounds reduced many first infections, especially at flowering. But mercury spray had no effect on established lesions on fruit. These sprays did not eliminate the trouble. The amount of mercury used was very small, at the rate of about one ounce to an acre of trees.

Nutman pointed out that if one considered a plantation which without "CBD" produced 1,000 lbs. clean coffee per acre, with the disease present it would probably only produce 500 lbs. If sprayed, production could be expected to be increased to about 650 lbs. In the closely associated work of Bock,[3, 4] it was reported that one per cent Perenox,

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used at fortnightly intervals, was as effective as Verdasan and certain other mercury containing fungicides. Griseofulvin, an antibiotic, also was promising. It can be seen that control of this disease is still far from perfect, but a great deal of research is currently being expanded on it with more and more success.

American Leaf Spot, Ojo de Gallo, Gotera; "Mycena citricolor" Berk. et Curt. (Sacc.)

The American Leaf Spot, or Ojo de Gallo, has never been found outside the Western Hemisphere. It was studied long ago, and can be serious on Arabica coffee and Robustas, as well as Liberica and Excelsa. It is caused by a remarkable fungus that is luminescent at night. Infection is by specialized gemmae or cabecitas, that are splashed around by raindrops or moved through contact with wet clothing and arms of workers.

Literature[7, 8, 18, 23, 25] indicates how Mycena leaf spot has been controlled by elimination of dense shade along with good pruning of coffee, by defoliating coffee trees and by fungicidal spraying. Bordeaux Mixture was the first spray used for this, and Barriga[1] has recently shown patented copper compounds are of comparable value. His work and that of a number of others demonstrate that Perenox, Crag, Basicop, Copper A, and others, if used with a sticker, gave good results. Fungicides lacking copper, like Dithane and Zineb, were relatively ineffective. In some work, not yet published, Captan was found to be of good effect, and that Fermate was of no value. Copper is known to be toxic to coffee,[23] a problem that Pérez noted as serious[18] in his sprays against Mycena. He alternated copper sprays with Dithane with more satisfactory effects. In some places, 2% copper sprays at monthly intervals, put on first when the rains begin and continued six months, have become standard practice.

However, such spraying does not eliminate the disease, and a search has been in progress to find an eradicant for it. In studies by Echandi[7] and Echandi and Segall,[8] it has been shown that mercury fungicides, such as Emmie, Puratized Agricultural Spray, Phix and Elgetol, had eradicating action. These were used combined with the sticker Film Fast. Results were very heartening, but harvested beans from sprayed trees, when tested for mercury content, were found to contain appreciable amounts of the poison. As there is no tolerance for mercury in foods for exportation to important consumers, the use of mercurial sprays for Ojo de Gallo was immediately stopped. Before these studies were abandoned, it was determined that dry season treatments with eradicants were much more effective than wet season sprays.

At about this same time, Castaño[5] demonstrated that arsenate of lead and arsenate of lime, used as insecticides, also have apparent eradicant effects on Ojo de Gallo. Unless properly handled, arsenates can be toxic to coffee. This has been under further study by other workers, as in India, where Tuzet has been used.[10] A number of eradicant compounds are being tested, and there is good reason to expect that a satisfactory eradicant for this disease will be found.

Weak Spot, Chronic Leaf Drop, Early Leaf Fall, often ending in Die Back; species of "Cercospora," "Glomerella," "Phoma," "Valsa," "Diplodia" and others

Often a condition is found in plantings of common species of coffee that results in weakened foliage. The start

is signified by appearance in leaf lamina of partially translucent, yellowish areas known as Weak Spots. The spots may develop small, irregularly shaped, somewhat necrotic sunken centers. Spores are not ordinarily produced on Weak Spots. Isolation and microscopic studies have shown presence of numerous semi-parasitic and more strongly active fungi growing in the spots, but apparently held in check in tissues. As the disease condition progresses, leaves are pushed out of normal orientation, and are turned back forcibly in characteristic fashion known as epinasty. These leaves then fall.

Such abnormal effect on leaves results in the denuding of fruiting branches. They are exhausted of nutrients, much before their time, besides being weakened from toxins absorbed from diseased leaves. In branches, immature leaf traces, left exposed from early leaf drop, are infected with common *Glomerella cingulata* and similar organisms. These branches then turn back, collapse, and the result is Die Back. This is an end product of Weak Spot or Early Leaf Fall, and it may cause 60% losses in crops. In East Africa, control of this disease complex increases production more than 300%.[12]

The disease condition is especially troublesome in neglected regions where soils are not fertile and no fertility is added, if soil is unprotected by either shade or mulch, if grasses choke the plantation, if pruning is given scant attention, and where poor management is coupled with intense exposure to the sun. It also has been found where apparently good horticultural practices are employed. Though it was studied in a minor fashion in Costa Rica, with observations on it in Puerto Rico, the only truly analytical work on it has been done in East Africa.[12, 14, 25, 28] At one time the trouble was considered a debility due to lack of some element. This was given further reasons as a theory, when it was found that what appeared to be a "tonic effect" on trees with weakened leaves resulted from applications of copper sprays.

Detailed studies during some of the earlier years showed "tonic effects" were due not to supplying of a lack of copper, but to the spray inhibiting incipient fungus infections. Good effects, similar to the "tonic effect" of copper spray, were found when other non-copper fungicides were used, such as Verdasan, and Lime Sulphur. Somewhat later, Grangier and Wellman[11] showed the organic fungicide Captan was a good material to control leaf spots in nursery plants. This material has since been used to control a chronic Leaf Fall that in unsprayed trees finally resulted in Die Back.

Amounts of spray and timing are of major importance[12] in control of the Leaf Fall and its end, Die Back. Leaf retention results in increased vigor of coffee trees, and the good response from greater vigor is especially measurable in the second year's crop produced under the spray schedule. The best spray programs are still to be determined, and this will require research wherever the disease occurs.

Copper fungicides caused some toxicity to leaves, and leaves that are either too young or too old suffer what can be interpreted as a shock effect. Spray with copper on young leaves causes hardening and some burn, and many leaves thus affected drop. Leaves that are somewhat matured to middle age are more resistant to copper sprays, but also are in a condition to suffer from Weak Spot. If

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sprayed properly they stay attached and do not become Spotted. In the much older leaves, there are less burns, but copper induces old leaves to drop long before they would have loosened normally.

Judging from such work as that of Jones,[19] the best time to spray against Weak Spot is several weeks after rains break the long dry season. He found that a 2%, high volume copper spray, used at the rate of 120 gal. per acre, gave good results. This was put on with standard spray equipment. With a newer so-called "air blast" type of sprayer, 30 gal. of 2% spray per acre gave as good or better control than with four times as much, using an old standard type of sprayer. When 30 gal. of 4% spray was put on with an "air blast" sprayer, it gave the best results of any. In the experiments reported, unsprayed fields produced at the rate of 303 lbs. of clean dry coffee per acre, and when properly sprayed they produced 1,049 lbs.

Discussion

According to some of the most careful thinkers, the most permanent and, in the end, most inexpensive method for control of coffee diseases is that of breeding and selecting resistant varieties. Some of this is in progress and much more work of the sort will be done in the future. This is a long process, and growers cannot wait for it; in the meanwhile, diseases must be controlled by spraying. In the years to come, coffee will be grown with greater intensity, and to keep it free from disease, spraying will be used more and more. It is probable that perhaps no time will come when spraying will not be used somewhere on coffee. In the meantime, all phases of coffee pathology will need increasing attention to keep abreast of horticulture and growing problems.

Where spraying is needed and applied, the results are easily seen. They can be readily demonstrated by research and demonstration programs. The very important problem of how much are the actual returns from spraying, economically, needs more study. This is in progress, and an outstanding example is the work of Robinson and Melville,[21] who have shown clearly how there is yearly cumulative good from the use of the findings from scientific research on coffee. Their statistical studies prove the consistent upward trend in production in a well-controlled area. In the study by these two men, perhaps the most important effects were from applying sprays properly, for reducing effects of fungus diseases.

List of spray chemicals mentioned, with indications of compositions

Arsenate of lead and arsenate of lime (two insecticides of standard use, applied originally to control leaf eating caterpillars), Basicop (basic copper sulphate), Blitox (basic copper chloride), Bordeaux mixture (reaction product of copper sulfate and calcium hydroxide), Captan (N-trichloromethylthiotetrahydrophtalamide), Copper A (tetra copper calcium chloride), Copper Sandoz (cuprous oxide), Crag (4-chloro-3, 5-dimethylphenoxyethanol), Cupravit (basic copper chloride), Cuprokylt (basic copper chloride), Dithane (disodium salt of ethylenebis (dithiocarbamic acid)), Elgetol (sodium 4, 6-dinitro-O-cresoxide), Emmie (1, 4, 5, 6, 7, 7-hexachloro-N-(ethylmercuri) bicyclo (2.2.1) hept-5-ene-2, 3-dicarboximide), Fermate (dimethyl ferric dithiocarbamate), Film Fast (a sticker composed of organic gums mixed with calcium carbonate), Fungi Copper Geigy (tetrachloro-p-benzoquinone), Griseofulvin (an antibiotic with fungistatic properties), Lime sulphur (calcium

polysulfides), Mercury copper chloride, Perenox (cuprous oxide), Phenyl mercury acetate, Phix (phenyl mercury acetate), Puretized Agricultural Spray (tris (2-hydroxyethyl) (phenylmercuri) ammonium lactate), Tuzet (tetramethylthyrium disulfur, dithiocarbamate of Zinc and arsenic), Verdasan (phenyl mercury acetate), Wet Col (a proprietary, prepared Bordeaux mixture), Zineb (zinc ethylenebis di thiocarbamate).

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★ **Advances in Coffee Production Technology**

selection of coffee types resistant to the Hemileia leaf rust

By BRANQUINHO d'OLIVEIRA, Centro de Investigação das Ferrugens do Cafeeiro
Estação Agronómica Nacional
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The writer is indebted to his colleague C. J. Rodrigues, Jr., for much help in the testing and screening of coffee selections and rust samples, and also in the preparation of tables. Some of the conclusions included in this article are taken from his unpublished results, for which my thanks are due.

In the early days of coffee agriculture, plantations were almost exclusively Arabica. The collapse of Ceylon's economy during the last quarter of the 19th Century, as a result of the spread of "orange rust" or "leaf disease" (*Hemileia vastatrix* Berk. et Br.) on the island's plantations of *Coffea arabica,* caused considerable alarm and initiated a new era in coffee growing.

"After 10 years had elapsed, the rust had reduced the average yield from 450 lbs. per acre to 200 lbs. per acre and lower. It caused monetary losses of about two million pounds of sterling annually, and in a short while planters were abandoning their fields because coffee had failed completely, and they soon changed to growing tea."[51]

Ceylon, the greatest coffee exporter before it was hit by "leaf disease," dropped in production from about 42,000 tons to less than 3,000 tons in a few years, while exports, totaling $15,000,000 in 1880, were reduced to $125,000 by 1909.[2]

Within a short period coffee rust invaded, with more or less spectacular effects, Arabica plantations in India, Java, Sumatra, Natal, Madagascar, Malaya, Philippines and wherever else *C. arabica* was being cultivated at low altitudes. Only the American continent, some Pacific and Atlantic islands, Angola and a few more African territories have not yet been reached by the rust.

Damages caused by *Hemileia* have been quoted often. Java's production fell from 123,111,100 lbs. in the years 1880-1885 to 10.872,210 lbs. in the years 1906-1908.[13, 14] The Phipippines exported coffee worth 2,474,210 *pesos* in 1889 and in 1922 and 1923 imported coffee to the value of 2,181,118 *pesos.*[17] Even small plantings in Southern Rhodesia[6] and the flourishing coffee industry of Transvaal[40] were completely ruined.

Wellman[51] describes in the following terms the tragic consequences of the *Hemileia* invasion of coffee plantations, terms that remind one of the great plagues of Biblical times:

"The very earliest attempts to control measures of *Hemileia vastatrix* on coffee were in reality measures of desperation. When the rust first came to a country, it spread very quickly and without hindrance, and caused damage of such magnitude that results were terrifying. Large companies in several lands went bankrupt, banks themselves failed, fine productive and well tilled plantations were abandoned and escaped back into bush where wild animals could once again roam unmolested, laborers and wealthy people starved, populations had to migrate, laborers were left to go back to savagery and disease, political turmoil followed; there were world shaking economic losses, families were destroyed, and men killed each other as well as committing suicide."

During the brilliant and exhaustive basic investigations carried by the young Cambridge botanist, H. Marshall Ward, on the ethiology, histology and biology of the Ceylon coffee disease between the years 1880 and 1882,[48, 49, 50] it was experimentally demonstrated that *H. Vastatrix* attacked not only all the old selections of *C. arabica* then in culture, but also one of the island's jungle species, *C. travancorensis.*

All the attempts to control the disease by cultural methods and by spraying the coffee plants with lime sulphur and other fungicides used at that time proved ineffective.

Attention began then to be called to some species of *Coffea* which, growing side by side with the infected Arabica plants, were not attacked or showed high tolerance toward the rust, in several places such as India, Java, Malaya, Philippines, Belgian Congo, Kenya, Tanganyika, etc.

Early reports from Singapore,[23] Tonkin,[39] Mauritius,[4] the East Indias,[25] etc., referred to the fact that, in spite of the severe attacks on Arabica coffees, Liberica trees were unaffected or only slightly attacked.

Thus *C. liberica* began to spread in those days and to replace *C. arabica* on the most affected regions at low altitudes, regardless of its inferior quality. The hope, however, proved to be groundless, and in a few years Liberica coffee lost its importance, mostly on account of severe attacks of *Hemileia.*

Meanwhile other species of *Coffea,* such as *C. congensis* in Madagascar,[18, 19, 20] and *C. robusta* (*C. canephora*) in Java[11, 12, 13, 14, 16, 24] proved to be highly resistant to *Hemileia* and of better quality than the Liberica coffees. Natural hybrids between *C. arabica* and species resistant to coffee

rust, chiefly *C. liberica,* have also been found in India,[7, 8] Reunion Islands,[1, 5] and Java.[3] Some of these hybrids, like "Kawisarie B", "Kawisarie D", and "Kilimas" from Java, have been under trial in many countries, owing to their claimed resistance to rust and their high yield. Other rust-resistant as natural hybrids, either having *C. arabica* as one of the progenitors or not, such as *C. congensis* x *C. canephora* (*C. ugandae*), known as "congusta"[15] or "conuga",[21] have been extensively propagated by grafting, or selfed to select better forms, and used in back-crosses to improve rust resistance in otherwise good coffees. One of these seems to be clone S. 26, from a plant selected on the collection of Dorbla Estate in West Mysore, India, which is the ancestor of the well known selection S. 288, one of the best sources of resistance to *H. vastatrix* in *C. arabica,* and a vigorous, spreading plant of good yield and quality.

The revolutionary landmark in Arabica improvement, however, came with the discovery in 1911 on Mr. Kent's estate, Doddengoodda, near Aldur, State of Mysore, India—of *C. arabica* plants resistant to leaf disease.[52] Selfed seed from a healthy and heavily yielding tree selected by Mr. Kent gave rise to an offspring of rust-resistant plants which have since been grown in India under the name of Kent's coffee. Their rôle in *C. arabica* breeding in many countries became fundamental, either when trying to introduce resistance in good quality Arabicas or when endeavoring to improve that of some partially resistant selections, such as S. 288.

The golden years of Kent's coffee were soon over, however, when Mayne[28] found a race of *H. vastatrix* able to infect it, and raised at the same time the alarming problem of physiologic specialization in this rust.

The fundamental research carried out by Mayne and his collaborators from 1932 to 1948 on the differentiation of physiologic races of *H. vastatrix*[32, 47] led to the characteri-

Table 1. Differential Clones for Physiologic Races of Hemileia Vastatrix and Groups of Coffee Seedlings (Indicated by Letter) According to the Type of Reaction They Represent

Physiologic races of Hemileia vastatrix and number of each type culture	Coffea arabica										Coffea canephora		Coffea racemosa		Mayne's physiologic races
	110_2, S4 Agaro	139_2, S12 Kaffa	87_1 Goldia	58_1, Sel. 353 L/5	33_1, Sel. 288-23	32_1, HK 1/6 (Kent's type)	63, Bourbon	263_1, Coffea canephora		Coffea racemosa					
	A	I	C	H	G	D	E	B		F					
I (22)	R	R	R	R	R	S	S	R		S					2
II (15)	R	R	R	R	R	R	S	R		S					1
III (37)	R	R	S	R	R	R	S	R		S					
IV (32)	R	R	R	R	R	R	R	S		P					
V (o) (51)	R	R	R	R	R	R	S	S ?		S					
VI (71)	R	R	R	R	R	R	R	R		S					
VII (139_2)	R	R	R	MS	MS	R	S	R		S					
VIII (166)	R	R	R	S	S	S	S	R		S					4
IX(oo)				R	S	R	S								3
X (137_2)	R	S	S				S			S					

(o) - This race needs confirmation; unfortunately, the original culture has been lost

(oo) - No culture of this rust exists in the C.R.R.C., and the reactions are according to Mayne's results.

R - Resistant; S - Susceptible; MS - Moderately susceptible

★ Advances in Coffee Production Technology

Selection of coffee types resistant to the Hemileia leaf rust

zation of at least four races in India, and showed both the impossibility of improving resistance to the disease without a careful survey of the parasite's specialization throughout the world, and the need of discovering new sources of resistance in different species of *Coffea* in their centers of origin.

The discovery, made in the Cameroons, of a new coffee rust attacking *C. arabica, H. coffeicola* Maubl. et Rog.,[26, 43] further complicated the problem of disease resistance in coffee breeding.

While the epidemics of *H. vastatrix* tend to lose their importance with altitude, *H. coffeicola,* on the contrary, becomes a menace only at places high above sea level, where it causes much chlorosis and leaf dropping, if attacks are severe. This second coffee rust has only been found until now in the French Cameroons, in the regions of Dshang, Nkongsamba and Quinquina,[53] and Fernando Pó and S. Thome,[37, 42] but may represent a potential danger. Quarantine precautions must be taken to prevent its introduction in other coffee regions of the world, as there seems to be no resistant plants of *C. arabica,* as indicated by numerous inoculations made by Rodrigues, Jr.,[42] who also demonstrated experimentally that *H. coffeicola* is able to infect other species of *Coffea* besides *arabica. C. canephora* and another species, probably *C. stenophylla,* were found to be naturally infected on the island of S. Thome; *C. racemosa,* although susceptible to all races of *H. vastatrix* so far tested in Portugal, is immune to *H. coffeicola,* and so are most of the seedlings of several selections of *C. abeokutae, C. canephora, C. congensis, C. excelsa, C. eugenioides, C. klainii, C. liberica* and the Brazilian hybrid *C. arabica* x *C. Dewevrei* (plant 387).[42]

In spite of the great difficulties involved in the selection of types of coffee resistant to *H. vastatrix,* highly valuable work has already been done in the Belgian Congo, India, Indonesia, Kenya, Tanganyika and Uganda. It has been the work of many people, both known and unknown, but among the former it would be unpardonable to forget the names of Cramer, Ferwerda, Lambers, Mayne and Narasimhaswamy, to whose patient labors modern coffee culture owes so much. The work continues, and basic investigations to tackle the problem are also in progress in many African, American and Asiatic countries, as well as at the "Coffee Rust Research Center" in Portugal.

Special mention is due the research at Balehonnur (Mysore, India) on the breeding and selection of *C. arabica.* The Arabica selections S. 288 (the selfed progeny of S. 26 already referred to), S. 795 (the progeny of a cross between S. 288 and Kent's), and S. 333 (the progeny of a cross between S. 31 (a sister plant of S. 26) and S. 22, a plant selected from Coorg Arabica), as well as the Robusta selection S. 274, are now largely in culture in areas where coffee plantations had been destroyed by the rust. The new series B.A. (Balehonnur Arabicas) and B.R. (Balehonnur Robustas) are under field trials. Other items of a well planned program

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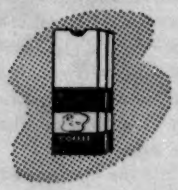

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of research started in India as early as 1915[9, 10, 32, 33, 36, 45, 47] include: the selfing of desirable progenitors for raising further progenies, such as S. 947 (F_n of S. 26), S. 881 (an Arabica from Sudan "which appeared resistant to four established races of leaf disease in India"), S. 964 (F_n of S. 288 x Maragogype), and S. 885 (*C. congensis* x S. 274 Robusta); hybridizations between desirable progenitors of the B.A. series to secure best combinations to produce vigor, resistance to leaf disease and high yield; back cross of interspecific hybrids of the type (*C. robusta* x *C. arabica* Kent's) x *C. arabica* Kent's, or between a natural hybrid of *C. robusta* x Dewamachi (an Arabica hybrid) with Arabica selections; and also exploratory inter-specific crosses involving *C. eugenioides, C. excelsa, C. liberica, C. canephora* (*robusta*), and *C. stenophylla* have been tried "with the object of building up resistance to leaf disease and combining the desirable qualities that are now dispersed in the several species."

In Portugal, a great number of coffee seedlings, belonging to nearly 1,000 selections, have been inoculated during the last five or six years with rust cultures isolated from about 200 samples of *H. vastatrix* collected on various countries of Africa and Asia (unpublished report, Rodrigues, Jr., and Oliveira).

The results show that brilliant achievements in the field of breeding for resistance to leaf rust have in fact been attained in some coffee research institutions, but that further sources of resistance may yet be found in other coffee centers of the world. The screening for physiologic races of *H. vastatrix*, on the other hand, proved that, besides the four races described in India,[47] several others can be characterized, using some additional differential hosts. Table 1. indicates the reactions of ten physiologic races of this rust and the type of reaction of the groups in which the tested coffees can be divided. Neither the number of races nor that of coffee groups can be considered as final, since our sampling is rather limited and rust cultures have been isolated chiefly from *C. arabica*.

Individual plants showing resistance to all the available races of *H. vastatrix* have been found on every species of *Coffea* tested, *C. bengalensis* and *C. racemosa* excepted. A few selections of some allogamous species, such as *C. abeokutae, C. canephora* (s.l.), *C. congensis, C. dibowskii, C. excelsa, C. klainii, C. liberica,* and of some inter-specific hybrids are formed by populations very uniform regarding their complete resistance to the rust. Probably because screening work has been more intensive on Arabica than on the others, a higher number of resistant plants has been found among the non-Arabicas. The opposite may probably be true when the work on the diploid preponderantly allogamous species will be more advanced.

Only two out of the ten physiologic races of *H. vastatrix* until now established are unable to infect *C. arabica;* one, race IV, was found once on *C. canephora* from Uganda, the other, race VI, has been collected often on *C. racemosa,* and is the only race so far identified in Portuguese East Africa. The other eight can be differentiated on five Arabica clones, which typify the five groups of resistance found in *C. arabica* (groups C, D, G, H and I).

GROUP C—Comprises plants susceptible only to races III and X of *H. vastatrix,* and is often referred to as "Geisha's type." Coffees with this type of reaction have been found in the following accessions of Ethiopian origin:[46] S. 9 Arba Gougou red tipped, S. 12 Kaffa, S. 17 Yrgalem, U. 1

Dalecho, Cioiccie, Moka du Sidamo B-E 5, N° 32, and N° 34; in several selections (unnamed) received through the Plant Introduction Section of the U.S. Department of Agriculture; and in two other selections, also from Ethiopian origin, Geisha and Dilla & Alghe, now in study respectively, in Tanganyika and Kenya Coffee Research Stations.[38, 46]

GROUP D—Usually designated as "Kent's type," and includes coffees susceptible only to races II and VIII of *H. vastatrix*. Plants with this type of reaction can now be found scattered wherever coffee is grown, and have been much sought as a source of resistance in breeding, not only in India but also in Kenya and Tanganyika. It is not rare to find, among the progeny of some old susceptible varieties, like the Indian "Old chick" or the selections "Bourbon" and "Blue Mountain Jamaica," plants carrying this type of resistance, probably as a result of some natural hybridizations.

To this group belong, besides the famous D K 1/6 from India and K 7 from Kenya, many other good selections, such as: Bourbon n° BO 72, Kent and Mysore from Belgian Congo; S. 16 Wollamo from Ethiopia; 286-7 and at least one source of Coorg from India; S. L. 6 and S. 33 from Kenya; F. 840, K. P. 228, K. P. 532, Kent's (K. P. 423), H 1, H 66 and Bourbon (N. 39) from Tanganyika. Trees of these selections now also exist in Brazil, Costa Rica and the U. S. A.

GROUP G—Also known as "S. 288-23 or Balehonnur type" was originally considered in this "Center" as a synthetic group, as the genetic origin of its resistance seemed to come from a plant of the Indian selection S. 26. Recently, however, after race VIII (Mayne's race 4) became available from Balehonnur, through the kind offices of Dr. C. A. Krug, of FAO (Rome), it has been found that one seedling of one accession sent from Ethiopia by Dr. P. G. Sylvain as S. 4 Agaro (entered in our collection as Cof. 110_5) and which had been considered until then as immune to all races (Group A), is in fact only partially resistant, showing the reactions of group G. The Arabicas of this group are susceptible only to races VIII and IX (Mayne's races 4 and 3) and moderately resistant to race VII of *H. vastatrix*. The following Indian selections have been found to possess this type of partial resistance: Sel. 288, Sel. 288-33, S. 333, Sel. 795, B.A. 3, B.A. 8, B.A. 10, B.A. 13, B.A. 16, B.A. 35, and B.A. 36. These selections, however, are still in segregation, and some plants in their progenies are fully susceptible to the races that attack the Arabicas (Group E). Two new Brazilian hybrids, obtained in Campinas, H. 3437 and H. 3439, also show this type of reaction.

The whole of the group, but particularly strains Sel. 288-23, S. 333 and Sel. 795, are the best available selections for cultivation in the areas where leaf rust is a limiting factor for growing Arabica coffees, not only on account of their resistance to a great number of physiologic races of *H. vastatrix*, but also because of their vigor and yield. In India, thousands of acres of coffee land have been recovered by the use of these selections and their area of culture is rapidly increasing. Descriptions of the selections are given by Narasimhaswamy.[35]

GROUP H—This is an Indian group of coffees susceptible to race VIII (Mayne's race 4) but resistant to race IX

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(Mayne's race 3), which we may designate as "S. 353 4/5 type." If the plants we possess in the "Coffee Rust Research Center" are of the true type, they are also moderately susceptible to race VII. However, no culture of race IX is available to us, and for that reason it has not been possible to distinguish the plants of this group from those of group G.

GROUP I—We call this group of coffees "Sylvain's type," and it includes Ethiopian Arabicas immune to all races of *H. vastatrix,* except race X. Seedlings with this type of reaction have been found in three accessions received from Ethiopia, as follows: Cof. 134, plant 4, and Cof. 635, plants 1, 3, 5, 6 and 7 (both selections belonging to S. 12 Kaffa); and Cof. 619, plants 2 and 6 (Selection N° 32). The progeny of seedling 134_4 is now under study and the preliminary results seem to indicate that this tree is homozygous for this type of reaction.

GROUP A—This is the "immune type" and comprises coffees resistant to all races of *H. vastatrix* so far known. Until now it includes: three Ethiopian seedlings of *C. arabica* (Cof. 110_2—S. 4 Agaro, Cof. 113_1 and Cof. 113_2—S.6 Cioiccie); two plants of a Timor self-fertile hybrid (Cof. 832_1 and 832_2) with the Arabica phenotype; and a large number of seedlings and some clones of diploid species of *Coffea.*

The three fully resistant Arabica seedlings, isolated from seeds collected by Dr. P. G. Sylvain in Ethiopia, seem to be, from the point of view of resistance to *H. vastatrix,* the most valuable material of this species until now found.[46]

The progeny of Cof. 110_2 is under study, and a high percentage of the seedlings already inoculated show total resistance to leaf rust.

Clonal material of all the immune Arabica seedlings now need to be field tested in areas where *H. vastatrix* is present, in order to confirm the resistance. Should they become infected under such conditions, then we would have one more physiologic race of the rust to deal with. It is necessary also to test, as soon as possible, the ecological adaptation and the economic value of these clones.

Immune seedlings have been found in more or less every accession of the diploid species of *Coffea* tested: *C. abeokutae, C. aruwimiensis, C. canephora* (s.l.), *C. congensis, C. engenioides, C., excelsa* (*C. dewevrei*), *C. dibowskii, C. klainii, C. liberica, C. neo-arnoldiana and C. stenophylla,* but not on *C. racemosa, C. bengalensis* or *C. salvatrix.* Some of these accesions deserve especial mention, as they seem to be formed entirely by seedlings immune to all the physiologic races of *H. vastatrix* available, among which are the following accessions of *C. canephora*:

From Java (Lains e Silva[44]). Bgn (Bangelan) 300; B.P. (Besukisch Proefstation) 4, B.P. 25, B.P. 39, B.P. 42, B.P. 46, B.P. 358, B.P. 447; Snmber Asin) 13, S.A. 34, S.A. 158.

From India (Balehonnur): S. 274.

From Belgian Congo: L. 36, L. 48, L. 93, 147, L. 215, L. 251.

These selections of *C. canephora,* others belonging to the species *C. congensis* and a few more to the hybrid Conuga, may be propagated extensively by grafting or by the use of seeds, employing the methods recommended by Ferwerda.[21, 22] As regards the other diploid species of *Coffea* already referred to, research must be carried along the same lines as those followed in Java for *C. canephora.*

GROUP E—Comprises the Arabicas susceptible to all

the physiologic races of *H. vastatrix* until now found on *C. arabica,* and unfortunately this is the type of reaction of most of the selections of Arabica now in culture in the world, such as Blue Mountain, Bourbon, Carmelita, Caturra, Chocolá, Colombie, Harrar, Guadeloupe, Jackson N° 2, Java Mocha, Kent's 489 (Ceylon), Laurina, Local Bronze n° 9 and n° 12, Marazan, Matari, Mocha, Mundo Novo, Old Chick, Pacas, Pacho, Padang, Pantgoer, Semperflorens, Ta-Ku, Tafari Kela, etc.; this means that all the famous selections of coffee in culture on the American continent, producing about 80% of the world coffee, are of this very susceptible type.

The remaining groups (B, F, and J, this last not yet included in Table 1.) comprise the dominantly allogamous species of *Coffea* and some inter-specific hybrids, and will have to be further divided, most probably, when more rust samples are collected on the diploid species, and when the screening is carried on a larger number of seedlings originating from seed collected in the centers of origin of the different species of *Coffea.* Differential hosts for groups B and J must be chosen as clones, because of the hybrid nature of the plants of these species.

GROUP F—This group, typified by *C. racemosa,* includes plants susceptible to all the physiologic races of *H. vastatrix* until now found on any species of *Coffea* except *C. arabica. C. racemosa* is represented in our collection by numerous accessions, and a few thousand plants have already been tested, all fully susceptible. The few seedlings of *C. bengalensis* and of *C. salvatrix* so far tested in the "Coffee Rust Research Center" also proved to belong to this group. Individual seedlings showing this type of reaction have also been found, among others giving the reactions of other groups, in various accessions of the following species: *C. abeokutae, C. aruwimiensis, C. canephora* (s.l.), *C. congensis, C. excelsa* (*C. dewevrei*), *G. eugenioides, C. dibowskii, C. liberica, C. neo-arnoldiana,* and *C. stenophylla.* This type of reaction is chiefly among accessions originating from seed collected on wild plants or on some cultivated ones which have not yet been selected for rust resistance, such as happens with the material received from Angola and with some accessions sent from Ceylon, French West Africa, Kenya, Ivory Coast, S. Thomé and Tanganyika. Plants of this fully susceptible group are very dangerous on the plantations, as they will always be infected with the rust, whatever physiologic race happens to be present. Care must also be taken to avoid plants of this type in breeding, to prevent the progenies from carrying their susceptibility to *Hemileia.* Fully susceptible seedlings have rarely been found in populations of *C. canephora* and *C. congensis,* in selections from the Belgian Congo, India and Java.

GROUPS B and J—These two coffee groups, formed by diploid, preponderantly allogamous species of *Coffea,* are differentiated by two physiologic races of *H. vastatrix,* race IV (type culture 32 from Uganda) and race VI (type culture 71 from Mozambique).

Coffee plants with the reactions of Group B have been found in the species *C. congensis* and *C. canephora* (s.l.) (*C. robusta* and *C. ugandae* included). Besides the type seedling, Cof. 263_1 (*C. congensis,* Uganda, Col. 15) several other plants have been found to belong to the group,

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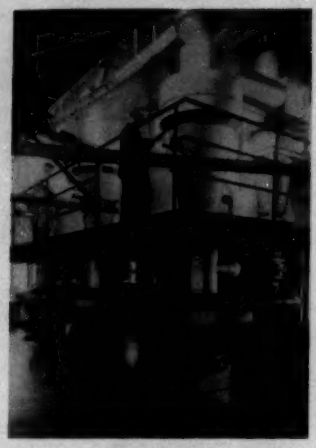

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such as: Cof. 264_8 (Uganda Col. 3) and Cof. 266_{15} (Bangelan Col. 9), both of the species *C. congensis* and originated from seed received from Brazil; Cof. 461_8 (Angola 115) and Cof. 464 (Angola 121), both *C. robusta* from Angola; and three plants (2, 4 and 9) of the accession Cof. 481, obtained from seed from Uganda as *C. ugandae*.

Group J has been differentiated by Reyes[41] who first found some plants congenial only to race VI. Plants with this type of reaction have afterwards been found in *C. eugenioides* (Cof. 126_8 and Cof. 203_4, from Kenya), in *C. arnwimiensis* (Cof. 491_8, from Ceylon), and in *C. excelsa* (Daubige, Cof. 166_{15}, and Lulla, Cof. 169_{39}, from the Ivory Coast).

Further screening for physiologic races of *H. vastatrix* will most probably reveal the existance of new types of coffee reactions to this rust, and then the problem of breeding for resistance may become still more complicated. It will be necessary to determine in the individual clones if rust reaction is transmitted to the progeny by one or more dominant factors, as Mayne found in the case of his Indian selections, and if it is possible to combine in the same plant the genetic factors responsible for the resistance to the different physiologic races, factors that may be scattered in different coffee types. A better knowledge of the number and distribution of the physiologic races of the rust is also badly needed, and an effort must be made to find the gametophytic host of *H. vastatrix*, to allow experimental inoculations to be made with teleutospores, and so investigating its evolutionary tendencies, the only way to forecast the appearance of new physiologic races.

Although the changing composition of rust populations may indicate that the work of the coffee breeders can be neutralized temporarily by the appearance of new biotypes of higher aggressiveness, and that attempts to grow coffee according to its type of resistance to *Hemileia* are doomed to have only a partial success, still it seems worthwhile to continue breeding and selecting coffee for rust resistance, either following the classic genetical lines used for the self-fertile species, as is the case with *C. arabica*, or according to the techniques described by Ferwerda[21, 22] for the allogamous species, such as *C. canephora*.

Proof that real progress can be achieved with these methods is to be found in the work carried in India and Java, the practical results of which are plainly seen in many of their selections. But the wide variety of morphologic, as well as physiologic types of *C. arabica* described by Sylvain[46] in Ethiopia, and that referred to by Ferwerda[21] in the F_1 of *C. robusta* seedlings introduced into Java, is a guaranty that if collections continue to be made of non-infected plants in places where many others are attacked, we may hope to enlarge still further our sources of resistance to *Hemileia*.

Planting clonal material of the resistant seedlings in the different ecological regions where the rust exists, besides being a test of their behavior, may also serve to trace unknown races and help to enrich our knowledge of the parasite's potentialities.

The following summary by Sylvain[46] was chosen to finalize this article, as it seems to condense most of the learning gathered by its author during years of work and observation in one of the most interesting regions for studying coffee:

"The behavior of the Ethiopian types concerning susceptibility to *Hemileia vastatrix* has a significance still greater

than its impact upon control of the disease. It confirms the richness of the germ plasm available and shows that the existing genetic variation is greater than that indicated only by morphological differences. From breeding programs we may obtain precious factors from these coffees including, for instance, resistance to other disease, lower transpiration rates, better root systems, higher photosynthetic rate, etc. The future of coffee breeding may lie in the development of varieties showing special physiological or anatomical characteristics which make them better adapted to specific areas, instead of trying to produce types based only upon high yield records without knowledge of their dependence upon ecological conditions."

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USDA sees good weather bringing bigger 1958/59 coffee crop

Continued favorable weather in several major coffee-producing countries has further increased prospects for the 1958/59 crop, according to the United States Department of Agriculture.

World exportable production is now estimated at 51,000,000 bags, compared with the first estimate in June of 50,000,000 bags. Last year's crop was 44,400,000 bags. Total production for 1958/59 is now estimated at 58,700,000 bags, compared with 52,500,000 last year.

World exports of coffee in 1958 will probably be near the 1957 level. Stocks in consuming countries are expected to be somewhat lower at the end of 1958 than at the beginning of the year, but are expected to be higher than at midyear 1958.

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biological control of insect pests in coffee

By A. R. MELVILLE, Chief Research Officer
Department of Agriculture
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The place of biological control in the modern science of entomology

Biological control, meaning in this case the control of agricultural pests by introduction of natural enemies, has now been practiced by entomologists for many years. The method has always had its strong advocates as well as its sceptical critics. The only reasonable approach is to regard biological control as one of the methods available to the economic entomologist for consideration and trial in connection with the search for means of controlling insect enemies of crop plants.

It is probably true that if a review were to be undertaken of all instances where the method had been attempted, it would be found that complete control, i.e., suppression of the pest below the economic damage level, has only been achieved in relatively few cases. In these cases, however, the result has been of the utmost value.

In a second group would be found a larger number of cases with a varying degree of success, which has frequently meant that other control measures were required less often.

The failures, undoubtedly the largest group, would include a high proportion of cases where the method was definitely well worthy of trial but would also include a proportion of cases where the chances of success must have appeared slender, even when the projects were initiated. It must be remembered, however, that the chemical weapons available to the entomologist in the period during and subsequent to World War II have become very much more powerful. These weapons were not available to workers before this period, and frequently the biological control approach was used because little other hope of success was apparent.

It can thus be said that the method now occupies a much clearer position than ever before and its usefulness has been greatly enhanced through advances in scientific knowledge of the subject. The development of increasingly rapid means of transportation in the world today must inevitably lead to the appearance of many problems capable of solution by this method. Most countries now operate plant import regulations which, while not infallible, do prevent in large measure the introduction and establishment of insect pests, but even though the officials concerned operate the regulations with the best will in the world, the occasional breakthrough occurs. The speed of modern air transportation has enhanced their problems.

An African laboratory assistant examines culture jars of the parasite "Anogyrus" near "Kivuensis" Compere in the insectary at the Coffee Research Station in Kenya.

Many of the historic cases of successful application of the biological control method relate to insects moved in a period when a great expansion of international trade was occurring and marine transportation was speeding up. At the same time, the need for plant import and quarantine regulations had not been fully realized; indeed, the sequence of events dictated the need for these.

In the classic cases, the pest species bred up more rapidly in its new environment, having shaken off its natural enemies, though this might not necessarily be the only factor operating. Frequently the country of origin of the pest was not known, and real progress could only be made once the identity of the pest had been discovered and the help of taxonomists and literature drawn upon to discover likely areas in which natural enemy explorations could be made. The economic entomologist with experience in this field gratefully acknowledges the invaluable assistance he receives from the taxonomists in this all-important matter of identification. It is not proposed to deal with the resourcefulness or ingenuity of entomological explorers in running down and shipping beneficial insects to the receiving territories. They have frequently worked under conditions of extreme difficulty in under-developed regions, and the methods

they used had to be improvised and adapted to fit conditions as they found them. Once a successful shipment had been accomplished, arrangements had to be made for careful screening to eliminate any harmful species which might have been included in the shipment before mass rearing and field liberations could be achieved.

While many of the spectacular cases of successful application of biological control were achieved in maritime islands, there is good evidence to show that success is not confined to such. American entomologists have achieved success in many projects in the U. S. A.[1] and the Kenya coffee problem, described in more detail later in this paper, is another outstanding example of successful application of the method in a continental area. In continental areas, it is possible for pest species to be moved accidentally from one ecological island to another when natural barriers formed of mountain ranges, deserts and inland lakes result in climatic conditions and discontinuous distribution of suitable host plants and preclude natural spread of host insects and their enemies.

Up to the present, successes have followed the use of parasites and predators, but though limited success has so far attended the use of bacteria, viruses, fungi, protozoa and nematodes, more research is likely to lead to results of importance with these agents in the future.

The use in recent years of persistent insecticides, such as DDT and dieldrin, has frequently demonstrated the great value of the control of pests achieved by parasites and predators. One of the most striking cases of interference with biological control followed spraying of citrus in California with DDT to control Citricola Scale (*Coccus pseudomagnoliarum* Kuw.) and Citrus Thrips (*Scirtothrips citri* Moult.)[2] Very heavy infestations of Cottony Cushion Scale (*Icerya purchasi* Mask.) appeared because the Vedalia Beetle (*Rodolia cardinalis* Muls.) was virtually eliminated locally. Similar results have been observed in coffee in Kenya, and in addition, use of persistent insecticides has, on occasion, raised to the status of major pests insects previously regarded as of minor importance or even rare. There is some evidence, too, that certain species of mites may become a serious factor in similar circumstances.

Biological control can be a powerful weapon when success is achieved. Its great advantages are cheapness, and before the advent of persistent insecticides, completeness. Nowadays, the entomologist is confronted with the problem of dovetailing the different control approaches and this can be a very complex business. It involves considerable knowledge of the insecticides in common use today, as well as a thorough understanding of the sometimes elaborate complex of insects which inhabit the crop plant the entomologist is called upon to protect. At times use has to be made of mass liberations of natural enemies to re-colonize areas seriously affected by insecticide applications. This has often meant the continuous mass-rearing of beneficial insects in preparation for such an eventuality.

Biological control in coffee culture

A review of entomological literature reveals that biological control has been applied in remarkably few insect problems affecting coffee culture. Part of the reason for

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this probably lies in the fact that the largest areas where coffee is grown in the world occur in the more humid tropics and subtropics, where fungus diseases are of greater significance. In Africa, on the other hand, and especially in Kenya, coffee is grown under much drier conditions, and here a vast complex of insects is associated with the crop. This is not to say that insect pests are not an important factor in coffee culture in the wetter areas, but the overall impression is gained that the effect of pests is less severe. In many cases, too, the pest species involved are indigenous, and this fact in itself reduces the potential value of application of the biological control technique. There remains, however, the obvious danger of pest introductions from one country to another, which may lead to further use of the method.

A notable exception to the general statement made above in regard to coffee pests in the wetter areas is the Coffee Berry Borer (*Stephanoderes* (*Hypothenemus*) *hampei* Ferr.) The Coffee Berry Borer parasite, *Prorops nasuta* Waterston, described by Waterston[3] from material collected in Uganda by H. Hargreaves, Senior Entomologist in that territory, was subsequently shipped to Java,[4] Brazil,[5-6-7] and Ceylon.[8] In Brazil the insect became permanently established, and according to Toledo, Duval and Sauer,[9] although it can be an important factor in suppressing the borer, the parasite tends, in common with its host insect, to be less active in dry years, and in wet years requires the assistance of sanitation measures combined with liberations if it is to achieve the maximum effect.

Reports on the increased use of insecticides against this pest indicate that biological control has not proved to be the answer to the problem, though it has undoubtedly played a useful role during the long period before suitable insecticides became available. Ultée[10] and Hutson[11] subsequently reported failures to establish this parasite in Java and Ceylon respectively.

Leefmans[12] mentions control of *Ceroputo* sp. on coffee in the Celebes by an introduction of *Cryptolaemus montrouzieri* Muls. from Java and Van der Goot[13] records a successful introduction of this same predator against *Phenacoccus iceryoides* Green in 1926 on coffee in the South Celebes.

Reports from the University of Puerto Rico[14-15-16] describe the introduction of the Braconid *Mirax insularis* Mues. from Guadeloupe to Puerto Rico against *Leucoptera coffeella* Guer., but it was finally concluded that the performance of this parasite was unsatisfactory as compared to its performance in Guadeloupe where it was stated to parasitize *Leucoptera* to a level of 65-85%.

It is thus evident that to date the most successful application of the biological control technique in coffee culture has been in the Common Coffee Mealybug problem in Kenya.

Biological control of the common Coffee Mealybug ("*Planococcus kenyae*" Le Pelley) in Kenya

The distribution range of the pest mealybug comprises an area of several thousand square miles to the east of the Great Rift Valley in Kenya, between the altitudes of 4,000 and 6,500 ft. above sea level. This highland area is an ecological island with barriers to the pest species in the form of high and cold hill country on the one hand, and near desert conditions on the other, where lack of suitable host species has presumably limited its spread. The mealybug was variously known as *Pseudodoccus citri* Risso., *P. lilacinus* Ckll. until it was described as a new species by Le Pelley[17] under the name of *P. kenyae*. This species has now been included in the new genus *Planococcus* recently erected by Ferris.[18] The mealybug was first reported as a serious factor in Kenya in 1923 and thereafter spread rapidly throughout the main coffee growing area East of the Rift Valley, not only on coffee but on a very wide range of host plants which included many peasant food crops. The effect on coffee and food crops was devastating, and the pest caused enormous losses. Some measure of control was achieved by grease-banding coffee trees to keep off the attendant ant *Pheidole punctulata* Meyr. but this method was expensive in material and labor, the latter mainly because it was essential to eliminate all ground contacts to ensure the effectiveness of the grease bands. In spite of these measures, losses were still high, because even in the absence of ants, the actual control was dependent on the appearance in strength of certain indigenous predators, mainly Coccinellidae. Biological control was quickly attempted, including the introduction of *Cryptolaemus montrouzieri* Muls. and a range of natural enemies of *P. lilacinus* from the Far East, but these attempts were unsuccessful. The correct determination of the insect as a new species played a key role in the ultimate successful control achieved, and incidentally explained some of the previous failures when non-specific parasites had been tried.

The writer[19] reviewed the evidence which could be adduced to show conclusively that the mealybug was a fairly recent introduction, put forward the concept of ecological islands within the continental land mass and suggested that the best hope of obtaining specific natural enemies lay in an area of Central Africa within the territories of Uganda and Tanganyika, where the same mealybug had been recorded. In this area, which lies between the source of the River Nile and Lake Victoria to the east and the Mountains of the Moon to the west, it was later shown conclusively that the insect was indigenous and under control by a large complex of natural enemies. The limits of this ecological island of indigenous distribution were later more accurately defined.

It is of passing interest to note that the direct distance between the islands of indigenous and introduced distribution is approximately 250 miles. The writer studied the natural enemy complex in Central Africa and shipped promising material to Kenya, where it was mass reared and liberated under an organization set up by Dr. R. H. Le Pelley, for many years Senior Entomologist with the Department of Agriculture in Kenya.

Although a number of species of parasites were established, the main success it attributed to the Encyrtid parasite *Anagyrus* sp. near *kivuensis* Comp. By mid-1939 the project began to look like being successful and thereafter the result can only be described as spectacular, in that the mealybug became very difficult to find over large areas previously infested. This state of affairs lasted for several years, after

which some trouble began to be experienced from localized areas in which the parasite control broke down, mainly as a result of the action of hyperparasites.[20] Nevertheless the situation was still very much better than it had ever been in the earlier period. These localized failures appeared to affect plantation coffee on large estates more than the dispersed small plots of peasant farmers, and it is also of interest to record that the depredations of the mealybug on peasant food crops never occurred again. The yam (*Dioscorea* sp.), an important peasant food crop, which, in some areas, had virtually been eliminated, began to be grown again.

It is now necessary to deal briefly with the role of the attendant ant *Pheidole punctulata* Meyr. This ant is exceedingly common and numerous in this part of Kenya and had been found from the earliest days of the problem to interfere with predacious insects by killing and eating eggs, larvae and adults of Coccinellid predators and generally performing a form of sanitary service to the mealybug by removing honeydew which would otherwise restrict the activities of the mealybug colonies and lead to heavy deposits of Sooty Mold fungus. The *Anagyrus* parasites which oviposit quickly did not appear to be very seriously deterred by the ants but subsequent events have shown that the ants have a considerable effect on their activities. The introduction in 1951 of dieldrin spray banding, in which the stems of the trees are sprayed with 1% dieldrin emulsion from ground level to a height of twelve inches, has led to the reduction of the mealybug to the status of a minor pest, because it has proved possible to attain a degree of ant control never approached before, which has enhanced the power of the natural enemy complex.

In the period before World War II, Le Pelley,[21] estimated that over the 17 years from 1923 to 1939, the mealybug problem cost Kenya coffee growers in crop lost and control measures applied £64,000 sterling per annum. For much of this time coffee was selling at from £30 to £70 per ton. In subsequent years, with the coffee price moving to a value of £500 or more per ton, and making allowances for increased costs of the chemicals which would have been needed together with much higher labor costs, the annual loss on plantations alone would have reached a figure of between £500,000 and £1,000,000 sterling. At a conservative estimate, the accrued value since 1939 of the biological control achieved could not be less than £10,000,000 sterling. It is further estimated that the total cost of applying the method would not exceed £30,000. These figures ignore losses to peasant food crops, and it is important to appreciate that successful control of the mealybug has made it possible to open up large areas of excellent coffee country for development of coffee growing by African peasants in the postwar period.

The modern approach to problems of insect control in Kenya Coffee

Past history in connection with the mealybug problem in Kenya has brought home to growers the importance of biological control, and while official policy has obviously dictated caution in regard to the use of persistent insecticides in coffee spraying programs, a majority of growers has fully appreciated the need for this.

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Numerous cases have occurred, however, where DDT spraying to control other important coffee pests, such as Coffee Thrips (*Diarthrothrips coffeae* Williams) and Antestia Bug (*Antestiopsis lineaticollis* Stal.) has produced outbreaks of mealybug and other insects normally suppressed by natural enemies. One of the most striking cases concerned the upsurge of the Tingid (*Habrochila ghesquierei* Schout.) from a position where it had never even been noticed to the status of a major pest. This insect is controlled very satisfactorily by a capsid predator, *Stethoconus* sp., which had been virtually eliminated by the DDT.

For years the usual control method used against Antestia Bug was pyrethrum in powder form. Pyrethrum is grown in Kenya, but in recent years it had been found too expensive to use at the rates previously employed. Pyrethrum is not persistent and has been found to be an excellent insecticide to use in the circumstances. Research is proceeding to discover ways and means of applying less pyrethrum aided by synergists to reduce the cost of using this insecticide. BHC compounds showed promise as insecticides which possessed the desired characteristics of high initial kill and subsequent rapid fade-out of activity, but recommendations of these had to be withdrawn following the discovery that BHC insecticides even in the purest form produced an undesirable taint in the crop which became known as 'Bricky Flavor.' Kenya coffee growers have the main aim of producing high yields of high quality coffee and any form of contamination whatever is not tolerated.

The problem facing entomologists is one of dove-tailing biological and chemical control against the background of improved crop production which follows the application of research results in other fields. The chemicals employed must be non-persistent in their effects on beneficial insects but be capable of a high initial lethal effect. At the present time, the less dangerous forms of organo-phosphorus insecticides, such as malathion and Diazinon, are proving valuable. Parathion is a powerful insecticide, but its use is discouraged because of the dangers involved in its use by a relatively primitive labor force. Where it is obligatory to use DDT, formulation and timing become important, and wettable powders have been found to be less persistent than emulsions. Use is also made of staggering treatments in time from one part of the farm to the next, and further, growers are encouraged to spray only parts of the farm where routine pest population tests show that control measures are really necessary. In all this work, detailed checks are made to make certain that the crop is unaffected by any pest control measures. The Government Research Laboratory maintains constant stocks of the parasite *Anagyrus* near *kivuensis* for re-colonization purposes if this is found to be necessary.

It is suggested that entomologists working in coffee in other parts of the world might well adopt a similar approach involving, as it does, a detailed knowledge of the biology of the insects associated with the crop and the properties of the range of insecticides available.

SUMMARY

1. Biological control must be regarded as one method of approach in insect control programs. With the speeding

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up of air transportation, this method is likely to have to be used frequently in the future, in spite of the existence of more efficient plant import controls.

Following the appearance of more powerful and versatile methods of chemical control of insect pests and advances in scientific knowledge of the technique of biological control, it should be easier in the future to assess the prospects of applying the method in insect control.

2. Instances of the application of the method to insects affecting coffee culture are briefly reviewed.

3. An account is given of the successful application of the method in the Common Coffee Mealybug problem in an ecological island in Kenya by introducing natural enemies from another similar island in Eastern Central Africa.

4. The need for entomologists working on coffee to study the means whereby biological and chemical control can be dovetailed is stressed.

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factors affecting the inherent quality of green coffee

By MAX DE GIALLULY, Instituto Interamericano de Ciencas Agricolas
Turrialba, Costa Rica

Coffee quality can be defined as the overall characteristic of the intrinsic components of the bean, which determines the degree of acceptability of the product within a given scale of comparison established by the consumer market.

To determine coffee quality, each of the components affecting the final classification must be examined separately by means of physical procedures and sensorial evaluation. Physical procedures applied to determine aspect of the bean—color, size and shape—can be readily operated after drying and hulling of the bean, and are routine in every processing plant by means of calibrated sieves and pneumatic separators followed by hand selection.

Until the end of the last century this was the only classification used to evaluate the quality of the final product. As coffee drinking became more popular and the market more selective for good quality, the organoleptic test of a representative lot sample became customary and is now as important a factor in quality grading as the physical appearance of the bean, particularly in the United States, where very little raw coffee reaches the consumer. The physical aspect of a lot sample determines the market value of the lot.

Despite constant research and sometimes very elaborate theories, to this date there is no known objective method to assess the organoleptic quality of coffee, and its evaluation, very subtle to define, can only be made by cup testing of the brew by professional testers, a process naturally subject to the variations of human judgment. Professional testers, however, can develop considerable accuracy in their evaluations, which are based on the grading of the three main components of the sensorial quality of coffee: acidity, body and aroma—and eventually, off-flavors. The organoleptic quality of a sample indicates to the roaster if the lot is to be used as a bulk product, or if it is a fine acid coffee of high quality, as a blender for batch mixing in a certain proportion with bulk coffee to achieve a standard quality representative of a trade mark. The latter should be uniform in quality from one batch to another in spite of the widely different coffees available at a given time on the market.

The abundant literature available on coffee research includes very little on quality, and that only in very general terms. While the botanist and the taxonomist were concerned with the nomenclature and the selection of the species, and the physiologist with the reaction of the different species under varied conditions of growth, it followed that the amount of production and the behavior of the tree were the key factors in selecting commercial varieties. Buying of the product was based upon the general reputation of a country, or a group of countries, for quality. In New York, for example, the term "Costa Rica" used to be applied to all coffees coming from Central America which was considered better than the best grade of Maracaibo, with a color varying from dark to light green, a heavy body and a fine rich flavor. Today, as before, coffee is bought on the reputation of a country, but a distinction is made according to altitude of growth species and variety and the method of processing. Hence a given country can now sell several grades, at widely varying prices. Higher grown coffees generally command a higher price than coffees grown at low elevation, and washed coffee brings higher prices than coffee processed by the dry method, now Costa Rica alone offers several grades of coffee on the market at different prices.

The physical appearance and the organoleptic quality of coffee being intrinsic to the bean, they can be altered if the bean is exposed to different treatment during growth, or if the tree bearer is subject to different physiological conditions.

The factors affecting the intrinsic quality of green coffee discussed in this paper can be classified in the following order:

Genetic
Environmental and Physiological

Genetic factor

Certain characteristics of quality, inherent to the germplasm, are fairly stable, and the overall quality of a lot sample can be indicative of the species and variety under test.

A key factor in studying quality in relation to the genetical factor is the necessity of observation of the trees under identical physiological and environmental conditions to control the effect such factors have on different species and varieties. The coffee collection maintained by the Inter-American Institute of Agricultural Sciences, Turrialba, seems to fill these requirements. Table 1 shows some observations on commercial varieties and species coming from this collection, processed under strictly similar conditions, i.e.

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without fermentation after pulping of the cherries ,and removal of the mucilage by mechanical abrasion.

Table 1. Flavor Characteristics of Different Varieties

Species	*Variety*	*Flavor Characteristics*
C. arabica	Laurina	Highly acid, low body, fruity
" "	Bourbon (red)	High acid, low body
" "	Cera	Fair body, acidity and flavor
" "	Caturra	Light, good body, flavorful, acid
" "	San Ramón	Good body, and flavor
" "	Blue Mountain Bourbon	Good body, flavor and mellow
	Xanthocarpa	Acid, fair body
" "	Le Roy	Flat, mild, low in body
" "	Purpurascens	Good body, flavor and sourness
" "	Bourbon Salvador	Good body, flavor and sourness
C. liberica	Abeokutae	Harsh, bitter and earthy, as compared against C. arabica
C. canephora	Common	
C. canephora	Quillou	
C. canephora	Robusta Uganda	

Table 1 shows considerable variations both among and within varieties and species, Bourbon Salvador being considered the best cup. These results apparently coincide with a study made in Colombia on two varieties of Arabica c.i.—Bourbon and Typica, of which the former showed a better quality.

The physical characteristics of these samples indicated even greater differences between varieties, as demonstrated in Table 2.

Tests in Table 2 were made by running the sample through a shape separator, weighing the amount of each shape, peaberry bean and flat bean, and then passing each sample through a series of sieves with openings of different sizes graduated to 1/64th of an inch. The amount remaining over in each sieve is weighed, and by determining the percentage of each weighing in relation with each sub sample, the following nomenclature is used for flat beans and peaberries of various sizes:

Flat beans
Bold: over sieve 17/64
Medium: over sieve 15/64
Small: under sieve 15/64
Peaberries
Medium: over sieve 11/64
Small: under sieve 11/64

Environmental factor

The characteristics illustrated in Tables I and 2, however stable, may change depending on the environmental and cultural practices which affect the physiology of the tree. An important factor of cup quality is elevation of growth, which has a significant effect on the body and acidity of the product.

A point study made by Victor Perez and Jorge Bonilla of STICA, in Costa Rica, with the cooperation of IAIAS on Arabica *var. typica* and *Var. Bourbon* gives the cup test results in Table 3.

Table 3. Results of Cup Tests of Two Varieties Grown at Different Altitudes

Altitude	*Variety*	*Body*	*Acidity*
4600 feet	Typica	2.65	2.20
4600 "	Bourbon	2.80	2 43
3300 "	Typica	1.65	1.55
3300 "	Bourbon	2.35	1.5
1500 "	Typica	1.65	1.00
1500 "	Bourbon	1.80	1.00

Classification: Body: Good, 3 points; fair, 2 points; flat, 1 point. Acidity: Very acid, 3 points; fair, 2 points; low, 1 point.

Further study by IAIAS on the effect of altitude on quality gave the cup test results in Table 4 for coffee from various commercial plantations in Costa Rica growing at an elevation of 400 to 5,600 feet.

Tables 3 and 4 indicate an increasing acidity with a higher elevation. However, contrary to the study shown in Table 3, Table 4 indicates that body seems to decrease as the elevation increases. Another effect of altitude upon quality is revealed on the examination of the physical aspect of the beans; Table 5 shows the percentage of peaberry in samples

Table 2. Shape and Size Classification of Different Varieties

		Shape Classification		*Size Classification*				
				Pea Berry		*Flat*		
Species	*Varieties*	*% Pea Berry*	*% Flat*	*% Medium*	*% Small*	*% Bold*	*% Medium*	*% Small*
C. arabica	Laurina	6.89	93.11	31.39	68.61	3.65	30.93	65.42
	Bourbon Red	10.45	89.55	89.46	10.54	70.78	19.69	9.53
	Cera	8.03	91.97	95.31	4.69	86.01	6.88	7.11
	Caturra	7.64	92.36	94.35	5.65	83.92	6.63	9.45
	San Ramón	4.51	95.49	89.96	10.04	78.93	11.74	9.33
	Blue Mountain Bourbon	8.53	91.47	95.65	4.35	83.18	6.63	9.19
	Xanthocarpa	3.89	96.11	90.01	9.99	73.47	5.92	20.61
	Leroy	7.26	92.74	20.91	79.09	3.21	36.54	60.25
	Purpurascens	11.11	88.89	47.65	52.35	10.79	49.40	39.81
	Bourbon Salvador	7.64	92.36	93.43	6.57	68.43	11.05	20.52
C. Libérica	Absokutae	31.27	68.73	70.61	29.39	34.65	30.42	34.93
C. canephora	Quillou	18.22	81.78	91.37	8.63	18.98	53.56	27.46
	Robusta Uganda	2.93	97.07	72.35	27.65	72.85	14.86	12.29

Table 4. Flavor Characteristics of Variety "Typica" Grown at Different Altitudes

Variety	*Altitude*	*Flavor Characteristics*
Typica	426 feet	Mild, light body
"	426 "	Mild, light body
"	5568 "	Light, body, fruity, acidy
"	5568 "	Light body, fruity, high acidity
"	4672 "	Fair to good body, good acidity, flavorful
"	4672 "	Fair to good body, good acidity, flavorful
"	2559 "	Heavy body, low acidity
"	2100 "	Earthy, heavy body, low acidity
"	4593 "	Fair to good body, good acidity, flavorful
"	2231 "	Earthy, heavy body, low acidity

of coffee coming from elevations varying from 350 to 5,300 feet:

Table 5. Classification by Shape of Beans According to the Elevation at Which Trees Were Grown

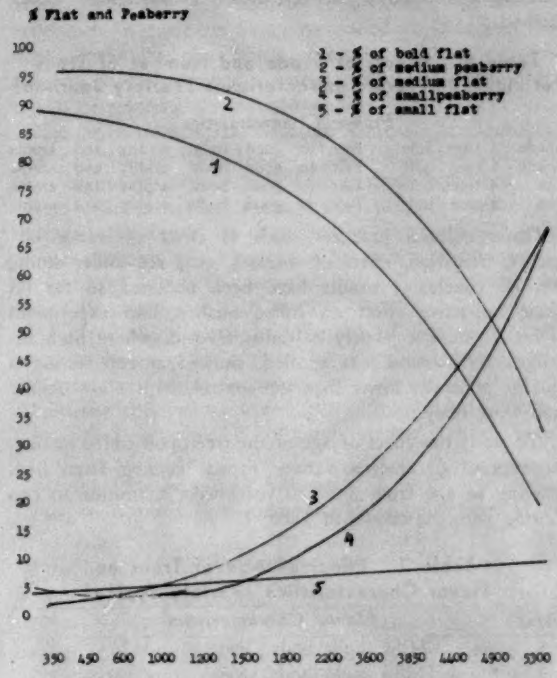
Elevation in Feet	*Peaberry % Total Sample*	*Flat Beans % Total Sample*
350	5.81	94.19
450	8.31	91.69
600	4.52	95.48
1000	4.71	95.29
1200	1.70	98.30
1500	5.02	94.98
1800	4.01	95.99
2200	8.99	91.01
3600	8.65	91.35
3850	5.12	94.88
4400	7.30	92.70
4900	2.12	97.82
5300	3.37	96.63

As the results indicate, the generally admitted belief that the peaberry is found in higher quality in lower elevations than at high altitude is subject to caution, and the occurrance of this characteristic should be investigated in relation with other factors.

Diagram A shows the results of a classification over sieves by size for both peaberry and flat coffee bean on the same sample used in Table 5.

Diagram A shows clearly the relation between bean size and elevation of growth, the curve for medium peaberry and bold flat bean both following the same pattern, indicating a decrease in bean size as the elevation increases.

Diagram A. Effect of Altitude on Size and Shape of Beans



Altitude, however, is not directly a determining factor of bean size, but rather is related to the climatological conditions; i.e. to the relative yearly humidity and rainfall, and Diagram A is relevent only to areas similar to Costa Rica, with an average humidity of 90% at 350 ft. and with an average rainfall of 2000 mm yearly at the same altitude, both decreasing with an increasing elevation.

In current specialized literature on coffee techniques, the desirability of planting trees under shade or at full sun is a highly controversial issue, and is the subject of various papers dealing with the physiology of the tree, its production, etc. To determine the advantages of these different methods of production in relation to the final quality of the coffee, preliminary studies were initiated at IAIAS. As

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indicated in Table 6, cup test results did not reveal any differences in quality between coffee grown under either method:

Table 6. Effects of Shade and Number of Trees Per Holes on Flavor Characteristics (Variety Bourbon)

		Flavor Characteristics
Shade	4 trees/hole	Fair to good body, acidity and aroma
Shade	1 tree /hole	Fair to good body, acidity and aroma
sun	4 trees/hole	Fair to good body, acidity and aroma
sun	1 tree /hole	Fair to good body, acidity and aroma

Other cultural practices, such as effect of minor elements, irrigation, effect of diseases, etc., are under study, but no conclusive results have been obtained so far on their respective effect on coffee quality. An experiment upon *C. arabica,* variety Salvador Hydrid, where high nitrogen fertilization was applied, showed at cup testing a quality generally lower than the control, with a low acidity and weak body.

To study the effect of age of the tree upon coffee quality, samples of *C. arabica,* variety Typica, coming from trees varying in age from 3 to 50 years were submitted to cup testing with the results in Table 7.

Table 7. Effect of Age of Trees on Flavor Characteristics (Variety Typica)

AGE	*Flavor Characteristics*
3 years	Mild, light body, acidy
4 "	Mild, light body, acidy
20 "	Light to fair body, acidy, best cup
50 "	Harsher, woody, more body, acidy

Diagram C. Percentage of Bold, Medium and Small Beans according to Fertilizer Treatments

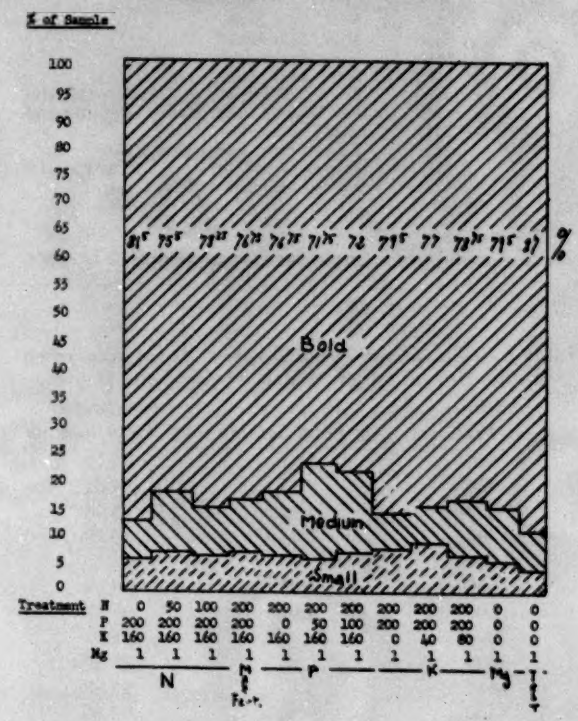

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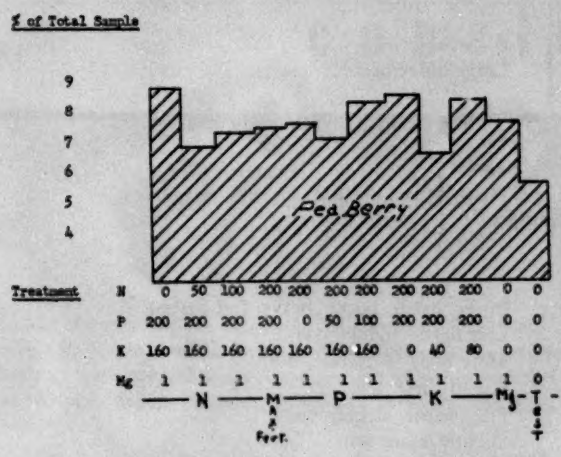
Diagram B. Percentage of Peaberry according to Fertilization Treatment



A determination of bean size made on tree varieties of Arabica, e.i., Caturra and Villalobos, grown in the sun, indicated that the variety typica produces a higher percentage of big bean than the other two varieties, with Caturra producing the smallest coffee bean, as illustrated in Table 8.

Table 8. Effect of Variety on Size of Beans

Variety	*% Bold bean in Sample*	*% Medium in Sample*	*% Small in Sample*
Villalobos	86	9	5
Caturra	79	14	7
Typica	87	6	7

The cup tests of the varieties in Table 8 showed better cup characteristics in favor of Caturra with a high acidity, followed by Villalobos.

Considering the ever increasing importance of fertilizer treatments in the new technology of coffee planting, an experiment is currently being conducted at IAIAS on the effect of nitrogen, phosphorus, potassium and magnesium on quality. The following is the description of this experiment and its first results in relation to quality:

The coffee trees in this experiment are all of *C. arabica*, variety typica, planted in 1950. The fertilizer applications were begun in May, 1952. Tree spacing is 2.50 x 2.50 meters planted under shade. The pruning method is Hawaiian and weeds are controlled by shoveling. This experiment consists of 12 treatments in four replications with six trees per plot. The samples included were combined from four pickings of each plot.

After picking, the samples were pulped, the mucilage adhering to the beans was removed by mechanical abrasion, and they were patio dried in parchment.

Fertilizer applications were made each year as follows:

January 1—Applied ¼ of total nitrogen; all of phosphorus; ½ of potassium.

April 1—Applied ¼ of nitrogen.

July 1—Applied ¼ of nitrogen; ½ of potassium; ¼ of nitrogen.

Treatment code

No—No nitrogen applied.

N50—50 kilograms of N per hectare applied during the year as Nitrate of Soda (16% N).

N100—100 kilograms of N per hectare applied during the year as Nitrate of soda (16% N).

N200—200 kilograms of N per hectare applied during the year as Nitrate of soda (16% N).

Po—No phosphorus applied.

P50—50 kilograms of P_2O_5 per hectare applied during the year as superphosphate (20% P_2O_5).

P100—100 kilograms of P_2O_5 per hectare applied during the year as superphosphate (20% P_2O_5).

P200—200 kilograms of P_2O_5 per hectare applied during the year as superphosphate (20% P_2O_5).

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Table 9. Effects of Different Fertilizer Treatments on Flavor Characteristics

Factors	*Treatment*				*Flavor Characteristics*
Nitrogen	N	P	K	Mg	
Repl. 1	50	200	160	1	All acid
	100	200	160	1	Little difference
	200	200	160	1	
	0	0	0	0	Slightly cleaner, slightly more acid
Repl. 2	0	200	160	1	Flatter
	50	200	160	1	" little difference
	100	200	160	1	"
	200	200	160	1	"
Phosphorus					
Repl. 1	0	0	0	1	Bitter, harsh, burnt, heavy (off-flavor)
	200	0	160	1	Less harsh, lighter body
	200	50	160	1	More body — milder, burnt little difference
	200	100	160	1	Slightly less acid
	200	200	160	1	Flat, burnt, lighter body
	0	0	0	0	Slightly more sour
Repl. 2	200	0	160	1	Harsher, flatter, astringent, hearthy
	200	50	160	1	Bitter, acid little difference
	200	100	160	1	Harsh, slightly less acid, metallic
	200	200	160	1	Harsh, slightly less acid, burnt protein
Potassium					
Repl. 1	0	0	0	1	Bitter, slightly peanuty
	200	200	40	1	Hearthy, burnt protein — vegetable flavor
	200	200	160	1	Hearthy, burnt protein — vegetable flavor
	200	200	160	1	Slightly more bitter, heavier body, less acid
	0	0	0	0	Milder quality
Repl. 2	200	200	0	1	Strong, more body, slightly peanuty
	200	200	40	1	Burnt protein, heavier body
	200	200	80	1	Harsh, bitter, strong, peanuty
	200	200	160	1	Bitter, peanuty
Control	0	0	0	0	Good, heavier body
Magnesium	0	0	0	1	Bitter, green sour, peanuty, burnt protein
Maximum Fertilization	0	0	0	0	Moderately different
	200	200	160	1	Both peanuty

Ko—No potash applied.

K40—40 kilograms of K_2O applied per hectare during the year as Muriate of potash 48% K_2O).

K80—80 kilograms of K_2O applied per hectare during the year as Muriate of potash (48% K_2O).

K160—160 kilograms of K_2O applied per hectare during the year as Muriate of potash (48% K_2O).

Mgo—No magnesium applied.

Mgl—1 pound per tree per year of "Emjeo" (30% MgO).

The Emjeo was applied in June, 1953; October, 1953; January, 1954; April, 1954; February, 1955; February, 1956.

This experiment, being preliminary, can lead to commentaries expressed only in general terms. The first analysis (Table 9) indicates that fertilizers affect both the organoleptic quality and the physical appearance of coffee, as demonstrated by the fact that the sample without application was considered as the best cup and that this generally showed a bigger quantity of bold beans.

The respective amount of fertilizers applied seems to be a determining factor in production of peaberry. This occurrence rises with the lack or the excess of one of the applied fertilizers in relation with the quantities generally applied. Fertilized treatments are responsible for a bean generally smalled than if there had been no fertilization. This is probably due to the fact that fertilized trees give a much bigger production and the total amount of bold, medium and small is much greater than from non-fertilized trees.

However, fertilization with varying amounts of notrogen and phosphorus applied with the maximum of other chemicals had very little effect on the flavor of coffee; the effect of potassium was more pronounced, with the flavor characterized as harsh, bitter, "peanuty and burnt. A distinct flavor difference was noted between coffee treated with magnesium but no other chemical, and the control; this sample was considered the less palatable. Cup test on maximum fertilization showed a moderate difference between this application and the control, and it seems that the quantity of fertilizers applied is not as important to quality as their combination and the respective quantity. The development of off-flavors in a sample might be originated during growth. The factor of quality most affected by all applications is acidity. Aroma the less subject to fertilizer treatment.

conclusions

By PIERRE G. SYLVAIN, Instituto Interamericano de Ciencas Agricolas
Turrialba, Costa Rica

The thought of the Editor of "Coffee and Tea Industries" to devote a whole issue of this magazine to advances both in coffee production technology, and in our knowledge of the plant which yields the crop, will certainly bear good fruit.

This reappraisal should be of great value to all research workers dealing with this tree or its seeds. It would be worthwhile to undertake a similar review every five or ten years to help in the orientation of future work.

The articles published here reveal some outstanding advances which have been made in relatively recent years, but we should not develop too much complacency therefrom, considering the fact that the road which lies ahead is still longer than that which we have already covered. Too many of the results obtained are still tentative for lack of completely reliable experimental evidence. Others are, up to now, of only local value, as they have not been tested under a sufficiently wide range of environmental conditions to be of general application.

The purpose of this last article is not to summarize all the previous contributions. We will, therefore, not again mention the achievements which have been reported in the preceding pages. It may be of some value, however, to draw attention to some of the more significant before dealing with the subject of future coffee research.

Perhaps one of the most rewarding results of recent investigations is that it has given us a clearer concept of how to obtain maximum sustained yields under conditions of intensive cropping.

The use of large fertilizer applications in conjunction with maximum intensity of solar radiation results in the large yields reported in the article by Cooil and Fukunaga. This finding indicates how the crop may benefit from high levels of mineral and organic nutrition and offers some basis for adapting these results to different environmental conditions. Such an adaptation is the "hedgerow" system of planting described by Cowgill. The physiological investigations reported by Alvim indicate that full sunlight *per se* does not seem to be detrimental to coffee, as it is believed to be in some quarters. Whether or not the plant should be grown under shade will depend upon local conditions related with edaphic, economic and social factors.

One of the most recent developments in our knowledge of coffee has resulted from the studies on mineral nutrition, which have shown the common occurrence of deficiencies of minor elements and their effects upon the crop. Although a few studies had previously been made on deficiency symptoms of plants in culture solutions, practically all the work on plants in the field has been carried out during the past ten years. The fact mentioned by Müller that boron fertilization resulted, in one instance, in an almost threefold increase in yield is indeed a significant discovery. The importance of minor or secondary elements is so well realized by coffee farmers in Costa Rica that the use of boron and magnesium in fertilizer mixtures is now common practice in many areas.

The genetic and breeding work which has resulted in the widespread distribution of better varieties is also of great practical importance. Krug, for instance, reports that the best Mundo Novo strains of coffee have produced in an average of six regional trials 240% more than the primitive Typia variety, and 80% more than the excellent Bourbon variety. According to Ferwerda, the work carried out with the Canephora species has also yielded clones of very great value. The value of the *Hemileia*-resistant selections is emphasized by the fact, reported by Krug, that strains of coffee with this characteristic are being widely distributed all over South India. India is apparently so far the only country where, in some areas, Robusta is being replaced by Arabica coffee. It may be foreseen that, with more resistant types becoming available through the work of d'Oliveira in Portugal, other countries will increase Arabica plantings which were curtailed by the spread of rust in certain areas.

The significance of insect pests and the great importance of biological control is emphasized by Melville's report. He estimates that the use of this method in regard to mealy bugs has saved, since it was used in Kenya, at least $28,000,000 worth of coffee. Probably some other pest of the crop could be controlled the same way at very little cost.

The better knowledge concerning the effects of mulch and irrigation on the coffee crop, as described by Medcalf, should make the economic production of coffee possible in some districts where long droughts are the limiting factor controlling yield. Results of some of the recent quality studies reported by de Gialluly throw a light on the effects of variety and environment upon certain characteristics of the green and roasted bean.

The survey published in this issue reveals the interesting fact that never before has there been such a number of institutions engaged in coffee research. The "Instituto Agronomico" of Sao Paulo at Campinas, Brazil, has ceased to be the only center dedicated to this crop in the Western Hemisphere, and since the 1940's, programs of coffee research have been carried out in various parts of Latin America. Outstanding contributions have already come from recently-established organizations in these countries. Meanwhile, in

Africa the French, the British and the Portuguese have stepped up their investigations on the crop, thus helping the outstanding increase in production within the past recent years.

Ethiopia, the home of the Arabica species, has just established an experiment station primarily devoted to this commodity. In Asia and India, pioneering work on breeding for resistance to *Hemileia* is being continued and is being followed up by work on similar lines in the Philippines. Indonesia is also following up, though on a reduced scale, the work that was formerly undertaken by the Dutch before the war.

With the background provided by this review concerning advances in coffee production which have resulted from recent investigations, and in view of the increasing interest in such investigations, it seems proper to look forward and consider some of the forms and objectives that future research in coffee might profitably adopt.

First of all, it is to be hoped that pressure of immediate problems will not cause us to neglect basic investigations which may bear valuable results in long range programs. In general, this type of investigation is lacking in the tropics, owing to limited funds and personnel, and also to the priority given to studies of immediate practical importance.

However, many of the advances mentioned in this issue could not have been possible without the basic work which was undertaken to establish their foundations. Considering these fundamental studies, we are, for instance, in need of an up-to-date taxonomic revision of the genus *Coffea*. A work of this type was published in 1947 by Chevalier[1] concerning the species Arabica, a series of papers has been issued by the institute at Campinas since the revision of the species was carried out by a group of investigators of this research center in 1939.[2] But such taxonomic surveys should be undertaken periodically, especially when new developments justify them.

Considering the better facilities for travel, including access to areas which were before little known to the outside world, the FAO recomendation regarding the proposed organization of three expeditions for the purpose of collecting coffee genotypes of interest, should be implemented. These expeditions would bring together the necessary material for a thorough revision of the genus *Coffea* with its different species and botanical varieties. The great advantages offered by the utilization of the various strains of *Coffea arabica* found in Ethiopia have been recently stressed by Sylvain,[5] and D'Oliveira has indicated in this issue that some of the Ethiopian introductions have shown immunity or high resistance to all the strains of *Hemileia* with which they were inoculated.

Another source of new germplasm will soon be available at the Inter-American Institute of Agricultural Sciences, at Turrialba, Costa Rica, where trees are being treated with gamma rays in order to induce mutation. Proper screening of this material, when it is available, may result in the discovery of plants possessing outstanding characteristics.

Considering this aspect of coffee research, it is our hope that physiological, anatomical and pathological studies will be employed more often as a tool to help the plant breeder. Correlation of anatomical and physiological characteristics with high production should be sought. An obvious approach would be to make a complete study of some very high and very low yielding types in order to interpret the possible meaning of the differences encountered. For instance, efficient carbohydrate production seems to be a limiting factor in sustained coffee yield, and it may be inferred that a type with a relatively high net assimilation rate, or a very expansive leaf area, might be more highly productive than others.

Another point is that, so far, most efforts have been devoted to the production of generally high-yielding types without giving sufficient consideration to the production of varieties possessing particular characteristics that make them valuable for special purposes. It can be assumed that, by a study of physiological factors such as rates of transpiration and water-absorption, types might be found greater drought-resistance. Strains better adapted to other unfavorable environmental conditions, such as excess of cold or heat, could also be developed along the same lines, thus making coffee production more reliable in districts now considered marginal.

In the case of disease resistance, great advances have been made in relation to leaf rust. There is no reason why similar work should not be systematically undertaken with other pathogens or pests. It is interesting to note in this respect a project now underway in Peru for the testing of a number of types for resistance to the particular species of nematodes common in the main coffee districts of this country.

In relation to quality, it is important to continue to appraise the various types available. Speaking of quality, we should not give attention solely to what are considered to be the best characteristics, but also to any specific features which make a type more suitable than another for any particular purpose. For instance, a very high rate of swelling of the bean on roasting is considered as an important feature on some markets, while others are only preoccupied by uniformity in the prices. If we know the varieties possessing this characteristic, we would be able to ship them to countries where they might bring a premium if well advertised.

Through better knowledge of the effect of the genetic constitution of coffee upon the various characteristics of the bean, we should be able to teach the importer not only to take note of the origin of his green coffee—i.e., Santos, Manizales, Coatepec—but to give his attention to varietal

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names, like Mundo Novo, Caturra and Villalobos.

Taking in view the needs of the immediate future, thought should be constantly given to the outstanding great problem of the industry, namely, the specter of diminished market prices while the natural development of producing countries results in higher wages and higher cost of land, both of which tend to increase the cost of production. Investigators should therefore constantly bear in mind the paramount importance of economic factors in coffee production. While in general, and up to a certain level, higher yields decrease production costs, this is not always necessarily so. Thus, the introduction of any new practice should not be recommended until good accounting has established the fact that increased returns are sufficiently large to make it profitable.

The help of the agricultural engineer and of the job efficiency specialist should be sought more often in the development of labor-saving devices. Zelenski's article has indicated some of the gains which may accrue from proper mechanization under certain conditions.

According to a survey made a few years ago on 15 farms in Colombia, the cost of coffee picking amounted to a little over half the cost of production excluding processing.[4] Without mentioning the old dream of a mechanical picker, it is possible that simple devices might make the operation much more efficient. This is a field of research practically untouched.

A possible solution to excess coffee production may be the greater use of by-products. Although this has been investigated in the past, there is still much to be learned on the subject. Some of the aspects of the problem were discussed by Martinez in a recent issue of this journal.[3]

It is our hope that equipment and personnel will be available to continue to expand the research projects now in operation in various countries. The recent impetus given to coffee investigations must not be allowed to give rise to an undue feeling of complacency. What is being done now is only a minor part of what should be done. The Western Hemisphere is not yet contributing its full share to the research program, considering the importance of the crop in this part of the world. Moreover, the danger looms that the continuous drop in prices of the commodity may discourage those who allocate funds to research. Such a short-sighted view would be calamitous to the long range program of expansion of the crop.

Coffee research needs the moral and financial support not only of the producers and their governments, but also of the importers and manufacturers. It may be pertinent to mention here the action of the American Cocoa Research Institute, organized by cocoa manufacturers, which has financed for the past ten years the Inter-American Cacao Center at Turrialba, Costa Rica, enabling it to carry out and foster programs of investigation in various countries of the hemisphere. Similar help from the industry concerned is lacking in coffee Research.

It is hoped that the present initiative of COFFEE & TEA INDUSTRIES, by indicating some of the recent achievements and by drawing attention to certain problems of research, will serve to renew interest in studies on coffee, and to increase the exchange of information between the various investigators concerned. There is a long road ahead, but the future of coffee as a crop and as a beverage, in a competitive society, lies in the carrying out of undertakings like those described in the survey published in this issue of COFFEE & TEA INDUSTRIES.

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Latin American coffee growers set six-month export quotas to implement 15-nation pact

Latin American coffee producers have reached unanimous agreement on the quantity of coffee they will export for the six months ending March 31st, 1959.

The formula establishes an historic base period which itself is based on exports for the first six months of the three coffee years beginning with 1954/55.

It provides that each country, over the six months beginning last October 1st can export the average percentage of coffee it exported in the first half of those three years, minus 5%, but not less than 50% of the year's exports.

Costa Rica's ambassador to the United States, Manuel G. Escalante, has been elected chairman of the board of directors of the Latin American Coffee Agreement.

Each signatory is represented on the board of directors. Voting is assigned to each country's representative on the basis of his country's coffee production in relation to world output.

Officials of the executive board of the Coffee Agreement gave this example to explain the quota basis.

From October to March, they noted, the importing countries absorb about 55% of coffee consumed during the year. In the second half of the year 45% of annual production is consumed.

Paton's Complete Coffee Coverage explains the formula as follows: El Salvador's exportable production for 1958/59 is estimated at 1,400,000 bags. From this (before any percentages is applied) must be deducted 125,000 bags, the retention quota under the terms of the Latin American Coffee Agreement (5% on the first 300,000 bags and 10% on the balance), leaving a balance of 1,275,000 bags.

Assume, also that El Salvador's exports during the October/March period of the three "base" years averaged 68.08%. A reduction of 5% would be 3.40%, which would mean that El Salvador's base under the formula would be 64.68% of 1,275,000 bags.

Next month controllers will be appointed to review past and current export statistics of the signatory countries. Another meeting of the Latin American Agreement group will be held during the second week of January to receive the auditor's report and to review the data. At present, the United States Department of Agriculture's fighres on exportable production are being used. Each country, if is wishes, may supply proof that these figures should be changed.

To cover administration and auditors' costs, an assessment of one cent per bag was voted, which it is estimated will raise about $280,000.

Special Coffee Study Group names officers, adopts program

The International Coffee Study Group, meeting in Washington, D. C., cleared the way last month for a search for long-term solutions to coffee's problems.

Erani do Amaral Peixoto, Brazil's ambassador to the United States, was elected president of a special Study Group of 12 countries charged with finding long-range answers.

Francois Gavotti, commercial counselor to the French Embassy, was named vice-president, and Frans Bakelandt, of Belgium, secretary.

The group also adopted a program and a policy. It was stated that all interested governments should be approached on problems of production, consumption or trading in coffee. In a study of the problems, it was said, the prime consideration should be to seek means of bringing about a balance between supply and demand.

Colombia's National Coffee Congress, meeting in Bogota, Colombia, suggested that the search for solutions include control of production.

Rio newspaper fears Red China has "gigantic" coffee plantings

The newspaper Correio da Manha said recently that Communist China was engaging in a "gigantic" coffee-planting program designed to ruin Latin-American economies, according to The New York Times.

It said the plan, inspired by the Soviet Union, already had resulted in the planting of 5,000,000 trees in the subtropical provinces of Yunan and Kwangsi. Since neither the Chinese nor the Russians are coffee drinkers, the planting is evidently for export, it said.

The newspaper urged the Brazilian government to study these "aggressive trade policies" before entering into full trade relations with the Soviet Union.

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U. S. housewives continue buying more coffee in third quarter

Housewives' purchases of coffee in the United States, which normally drop during the summer months, continued the trend established in the first and second quarters of this year and showed an increase of 1.4% during the third quarter of 1958 and over the same period in 1957, the Pan-American Coffee Bureau reports.

U. S. households used a total of 382,900,000 lbs. of roasted coffee, represented in both regular and instant, in preparing the family brew, compared to 377,600,000 lbs. during the same period of 1957, according to a continuing survey made for the Bureau by the Market Research Corp. of America.

Sales of regular roasted coffee in cans and bags continued the gains shown earlier, though the rate of increase was slightly lower, amounting to 0.3% over the same quarter in 1957.

Instant coffee sales, which continued the levelling off begun around the first of the year, also showed a lower percentage of increase, amounting to 5.5% over the same quarter of 1957.

Coffee purchases in vacuum cans and bags totalled 302,700,000 roasted pounds from July through September this year, up from 301,700,000 for the same period in 1957.

Instant coffee sales increased to 213,800,000 two-ounce units, as against 202,600,000 for the third quarter in 1957, PACB reported.

Colombia, Sweden in barter agreement on coffee

Colombia and Sweden have concluded an agreement to exchange Colombian coffee for Swedish self-propelled diesel railway cars, according to the United States Dept. of Agriculture's Foreign Crops and Markets.

The National Coffee Federation of Colombia is allowing the National Railroads $300,000 credit to finance imports of the Swedish passenger-car equipment.

The establishment of a coffee credit instead of straight barter will allow Sweden to import coffee as required, rather than swamping the market with untimely imports.

NCA develops youth market ammunition with 16-page insert for teenagers

In its continuing efforts to develop the coffee-drinking potential of the youth market, the National Coffee Association sponsored a 16-page, photo-illustrated insert in the October 31st issue of Scholastic Magazines, national publications for high school students.

The insert, entitled "Everybody Wonders," is designed as an informal handbook for teenage students to help them solve some of the problems of growing up. Among the topics touched upon are: dating, grooming, studying, safe driving, health and popularity.

The booklet has an entertaining and informative style that will have strong appeal for young people. The subject of coffee has been purposely underplayed by NCA. Coffee drinking is subtly related to the social and school activities of young people. Brief tips on coffee brewing and coffee recipes are given at the bottom of seven pages of the handbook.

NCA President John F. McKiernan feels the coffee industry should make friends with the influential and constantly expanding youth market. Commenting on the beverage habits of young people, Mr. McKiernan said: "When teenagers are old enough to drive automobiles, have dates, and hold part-time jobs, they're old enough to drink coffee."

According to independent surveys conducted by Benson & Benson and the Institute for Motivational Research, Inc., three out of five parents approved their children's drinking coffee at the age of 16 or under.

"Everybody Wonders" will be distributed as a part of Scholastic Magazines' senior high school editions, and will reach a total reader audience of more than 3,500,000 students, teachers and parents.

It will also be distributed in reprint booklet form through NCA member companies.

PACB makes photo exhibit on coffee available on loan or purchase

The Pan-American Coffee Bureau has announced that its 24-photograph exhibit, "A Pictorial Story of Coffee," is now available for loan or purchase by coffee companies.

PACB pointed out that it has received so many requests from coffee companies for photographs to be used in decorating company offices, for store promotions and for trade shows, that it decided to make copies of the exhibit available at a cost of $130 plus shipping charges.

The exhibit depicts the principal methods of coffee growing and production from the time the seeds are planted until the green beans are shipped to the consuming countries.

The black-and-white matté-finish photographs, mounted on sturdy Masonite and treated so as to be washable, vary in size from 8" x 10" to 30" x 40". Displayed to best advantage, they cover a wall area 30 feet long and about 4 feet deep.

The exhibit is flexible, however, and is still effective when only part of it can be used because of space limitations.

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By MARK HALL

THE BUSINESS MAN AND THE PROFESSOR

The business man has to be right. If he is wrong, his business suffers, and then in walks the creditors.

He has to do a lot of hard thinking of an original character, extremely technical, and based on long experience or natural genius. He may not be able to write a treatise on his problems, or even know how to spell, but to succeed takes a very high order of intelligence and talent.

The professor needs to know how to think, and think convincingly, either in the written or spoken word. He might spend more time introducing his subject than in expounding it. He might begin from a wrong premise and support it with such a brilliant and convincing argument that the orginal premise would be obscurbed. He might overwhelm with facts, arranged in such fantastic order and brilliant presentation that a humble but successful business man would be perplexed.

Why are so many students of the last generation leaving college with the impression that business is bad, anti-social and dishonest? One girl graduate was 40 years late in her impressions of the evil of the railroads. Reforms had corrected abuses, but the professors liked it better when they had something to condemn.

Of course, this does not apply to all professors, but the effect of the group adverse to business is still apparent in the attitude of students today.

What the business man needs is not only to show good judgement in his business, but to become more articulate—especially to the younger generation.

Paxton & Gallagher business sold to Swanson brothers

The Paxton & Gallagher Co., Omaha, roasters of Butter-Nut Coffee, has been sold to Gilbert C. and W. Clarke Swanson, and associates, for $11,548,226.

Subject to approval of stockholders, the sale will be effective December 31st.

Paul C. Gallagher, president of Paxton & Gallagher, will remain on the board of directors.

The hardware and Butter-Nut divisions of the company were sold. The Western Wine and Liquor Co., a wholly-owned subsidiary, was not involved in the sale.

The Swansons formerly owned the C. A. Swanson & Sons Co., Omaha, a frozen and canned foods firm, which affiliated with the Campbell Soup Co. in 1955.

Gilbert Swanson will serve as chairman of the board of Paxton & Gallagher and Clarke Swanson will be president.

They said these are the only executive changes contemplated.

Lewis Sherman, dead at 72, once a national leader in coffee

Lewis Sherman, president of the Jewett and Sherman Co., Milwaukee food manufacturers, died recently at the age of 72.

He had headed the company since 1915. Jewett and Sherman was founded in 1867 with Mr. Sherman's grandfather, William M., as a manager. The firm originally dealt in spices and coffee, but in later years entered the food manufacturing field.

The company packs and markets condiments under the Holsum label and coffee under the Gold Bond label.

Mr. Sherman joined the company in 1907 after his graduation from the University of Wisconsin.

Mr. Sherman took a leading role in industry affairs. He was president of the National Coffee Roasters Association in 1926.

Survivors include his wife, two daughters, two sisters and three grandchildren.

Coffee Pavilion at Brussels Fair gets grand prize in food division

The Coffee Pavilion at the Brussels International Exposition won the grand prize as the best exhibit in the Food Specialties Division, the Pan-American Coffee Bureau was informed by fair authorities.

The Coffee Pavilion was sponsored jointly by PACB and the Belgian Office du Cafe.

One of the most popular exhibits at the World's Fair, the Coffee Pavilion featured a complete coffee roasting plant, a coffee bar and a variety of pictorial displays covering the history and romance of coffee among many peoples.

Suggest surplus coffee be turned into solubles in producing countries

Turn coffee surpluses into solubles—they will take up one-third less room and hold quality longer.

This idea was put forward recently by El Cafe de El Salvador, published by the Coffee Association of El Salvador.

The publication suggested the building of a new soluble plant in El Salvador, in view of current overproduction, which makes it difficult to sell an entire crop to consuming countries.

Also, the publication pointed out, demand for instant coffee is increasing in El Salvador and abroad.

JFG may build new soluble plant

A new plant to manufacture instant coffee is under consideration by the J. F. G. Coffee Co., Knoxville, Tenn.

The company has taken an option on three acres of land near the Hoover freight terminal, for this purpose.

Floyd P. Goodson, Sr., chairman of the board of J. F. G. Coffee, was reported as saying that plans have been made for the building, but no architect has been engaged as yet.

Ship sailings

A SUMMARY OF INWARD-BOUND SCHEDULES ON THE COFFEE AND TEA BERTHS

Ports and dates are subject to change, should exigencies require. Moreover, lines may schedule sailings not shown in this schedule.

Abbreviations for lines

Ahl Trans Car—Ahlmann Trans Caribbean Line
Alcoa—Alcoa Steamship Co.
Am-Exp—American Export Lines
Am-Pres—American President Lines
Arg-State—Argentine State Line
Am-W Afr—American-West African Line
B-Afr—Belgian African Line
Barb-Wn—Barber Wilhelmsen Line
Barb-Frn—Barber-Fern Line
Barb-W Afr—Barber-West African Line
Bl-Dia—Black Diamond Steamship Co.
Brodin—Brodin Line
Col—Columbus Line
Cunard—Brocklebanks' Cunard Service
Delta—Delta Line
Dodero—Dodero Lines
Dreyfus—Dreyfus Lines
Ell-Buck—Ellerman & Bucknell S.S. Co.
Farrell—Farrell Lines
Grace—Grace Line
Granco—Transportadora Gran Colombiana, Ltda.
Gulf—Gulf & South American Steamship Co., Inc.
Hellenic—Hellenic Lines Ltd.
Hol-Int—Holland-Interamerica Line
Independence—Independence Line
Isthmian—Isthmian Lines, Inc.
JavPac—JavaPacific Line
Lawes—Lawes Shipping Co., Inc.
Lloyd—Lloyd Brasileiro
Lykes—Lykes Lines
Maersk—Maersk Line
Mam—Mamenic Line
Mormac—Moore-McCormack Lines, Inc.
Nedlloyd—Nedlloyd Line
Nopal—Northern Pan-American Line
Norton—Norton Line
PAB—Pacific Argentine Brazil Line
PacFar—Pacific Far East Line, Inc.
PacTrans—Pacific Transport Lines, Inc.
Pioneer—American Pioneer Line
PTL—Pacific Transport Lines, Inc.
R Neth—Royal Netherland Steamship Co.
Robin—Robin Line
Royal Inter—Royal Interocean Lines
SCross—Southern Cross Line
Sprague—Sprague Steamship Line
Swed-Am—Swedish American Line
Torm—Torm Lines
UFruit—United Fruit Co.
Wes-Lar—Westfal Larsen Co. Line
Yamashita—Yamashita Line

Abbreviations for ports

At—Atlantic ports
Ba—Baltimore
Bo—Boston
CC—Corpus Christi
Ch—Chicago
Chsn—Charleston
Cl—Cleveland
De—Detroit
Ga—Galveston
Gf—Gulf ports
Ha—Halifax
Ho—Houston
HR—Hampton Roads
Jx—Jacksonville
LA—Los Angeles
Ml—Montreal
Mo—Mobile
NO—New Orleans
NY—New York
Nf—Norfolk
NN—Newport News
Pa—Philadelphia
Po—Portland
PS—Puget Sound
Sa—Savannah
SD—San Diego
SF—San Francisco
Se—Seattle
St. Jo—Saint John
Ta—Tacoma
Va—Vancouver

COFFEE BERTHS

ABIDJAN

SAILS	SHIP	LINE	DUE
11/14	Del Alba	Delta	NO12/1
11/27	Afr Pilot	Farrell	NY12/12
12/2	Daisa	Bl-Dia	Bo12/16 NY12/18
12/5	Del Campo	Delta	NO12/22
12/8	Jartvig	Maersk	NY12/24 LA1/22 SF1/24
12/12	Afr Dawn	Farrell	NY12/27
12/26	Del Monte	Delta	NO12/12
12/28	Afr Glen	Farrell	NY1/12
1/2	Lorima	Bl-Dia	Bo1/16 NY1/18
1/8	Kirsten	Maersk	NY1/24 LA2/22 SF2/24
1/15	Afr Pilgrim	Farrell	NY1/30
1/16	Del Sol	Delta	NO2/2
1/29	Afr Grove	Farrell	NY2/12
2/2	Loulea	Bl-Dia	Bo2/16 NY2/18
2/10	Afr Pilot	Farrell	NY2/25

ANGRA DOS REIS

11/13	Hardanger	Wes-Lar	LA12/13 SF12/15 Po12/22 Se12/24 Va12/25
11/13	Del Viento	Delta	NO12/1 Ho12/6
11/27	Del Mundo	Delta	NO12/51 Ho12/20
12/6	Evanger	Wes-Lar	LA1/2 SF1/4 Po1/11 Se1/13 Va1/14
12/11	Del Rio	Delta	NO12/29 Ho1/3
12/26	Del Aires	Delta	NO1/13 Ho1/17
1/2	Del Santos	Delta	NO1/20 Ho1/24

BARRANQUILLA

11/16	Lovland	UFruit	NY11/29
11/20	Candida	UFruit	Ho11/26 NO11/29
11/30	Choluteca	UFruit	NY11/13
12/4	Mama	UFruit	Ho12/10 NO12/12
12/14	Lovland	UFruit	NY12/27
12/18	Candida	UFruit	Ho12/24 NO12/26

BARRIOS

11/10	Jytte Skou	UFruit	NY11/17
11/15	Christiane	UFruit	Ho11/19 NO11/21
11/17	Arctic Tern	UFruit	11/24
11/22	Lempa	UFruit	Ho11/26 NO11/28
11/24	Trolleggen	UFruit	NY12/1
11/29	Leon	UFruit	Ho12/3 NO12/5
12/1	Jytte Skou	UFruit	NY12/8
12/6	Christiane	UFruit	Ho12/10 NO12/12
12/8	Arctic Tern	UFruit	NY12/15
12/13	Lempa	UFruit	HO12/17 NO12/19
12/15	Trolleggen	UFruit	NY12/22
12/20	Leon	UFruit	Ho12/24 NO12/26
12/22	Jytte Skou	UFruit	NY12/29

BUENAVENTURA

11/13	Cd. de Cali	Granco	Ho11/22 NO11/26
11/16	Merchant	Gulf	Ho11/24 NO12/2
11/17	Rio Magdalena	Granco	LA11/29 SF12/1 Va12/10
11/18	Hans P. Carl	Granco	LA125 SF12/8
11/24	Santa Anita	Grace	LA12/6 SF12/8 Pa12/13
11/28	Trader	Gulf	Ho12/6 NO12/13
12/8	Santa Fe	Grace	LA12/22 SF12/26 PS12/30

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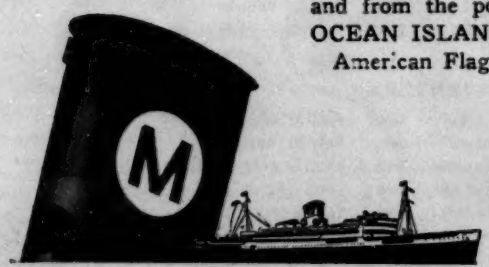

MOORE-McCORMACK *Lines*

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SAILS	SHIP	LINE	DUE
CORTES			
11/11	Jytte Skou	UFruit	NY11/17
11/12	Christiane	UFruit	Ho11/19 NO11/21
11/18	Arctic Tern	UFruit	NY11/24
11/19	Lempa	UFruit	Ho11/26 NO11/28
11/25	Trolleggen	UFruit	NY12/1
11/26	Leon	UFruit	Ho12/3 NO12/5
12/2	Jytte Skou	UFruit	NY12/8
12/3	Christiane	UFruit	Ho12/10 NO12/12
12/9	Arctic Tern	UFruit	NY12/15
12/10	Lempa	UFruit	Ho12/17 NO12/19
12/16	Trolleggen	UFruit	NY12/22
12/17	Leon	UFruit	HO12/24 NO12/26
12/23	Jytte Skou	UFruit	NY12/29
CRISTOBAL			
12/17	Candida	UFruit	Ho11/26 NO11/29
11/29	Copan	UFruit	NY12/6
12/1	Marna	UFruit	Ho12/10 NO12/12
12/15	Candida	UFruit	Ho12/24 NO12/26
DAR es SALAAM			
11/29	Rondo	Nedlloyd	NY1/1 LA1/20 SF1/24 Po1/31 SF2/4 Va2/7
12/3	Afr Lightning	Farrell	Bo1/10 NY1/12
12/18	Afr Rainbow	Farrell	Bo1/26 NY1/27
12/31	Friesland	Nedlloyd	NY2/2 LA2/21 SF2/25 Po3/4 Se3/8 Va3/11
1/18	Afr Moon	Farrell	Bo2/23 NY2/25
1/25	Samarinda	Nedlloyd	NY2/27 LA3/18 SF3/22 Po3/29 Se4/2 Va4/5
DJIBOUTI			
12/12	Rondo	Nedlloyd	NY1/1 LA1/20 SF1/24 Po1/31 Se2/4 Va2/7
1/13	Friesland	Nedlloyd	NY2/2 LA2/21 SF2/25 Po3/4 Se3/8 Va3/11
2/7	Samarinda	Nedlloyd	NY2/27 LA3/18 SF3/22 Po3/29 Se4/2 Va4/5
DOUALA			
11/18	Dalsa	Bi-Dia	Bo12/16 NY12/18
11/27	Hartvig	Maersk	NY12/24 LA1/22 SF1/24
12/7	Afr Glen	Farrell	NY1/12
12/18	Lorima	Bi-Dia	Bo1/16 NY1/18
12/27	Kirsten	Maersk	NY1/24 LA2/22 SF2/24
1/9	Afr Grove	Farrell	NY2/12
1/18	Loulea	Bi-Dia	Bo2/16 NY2/18
EL SALVADOR			
11/14	Santa Cruz	Grace	LA11/25 SF11/26 PA11/30
11/20	G. Ferraris	Italian	LA11/27 SF11/29 Va12/9 Po12/13
11/23	Hans P. Carl	Granco	LA12/5 SF12/8
11/23	Carimare	French	LA12/2 SF12/4 Va12/8 Se12/12 Po12/14
12/29	Santa Anita	Grace	LA12/6 SF12/8 PA12/18
GUATEMALA			
11/16	Santa Cruz	Grace	LA11/25 SF11/26 PS11/30
11/21	Ferraris	Italian	LA11/27 SF11/29 Va12/4 Se12/9 Po12/13
11/26	Carimare	French	LA12/2 SF12/4 Va12/8 Se12/12 Po12/14
11/26	Hans P. Carl	Granco	LA12/5 SF12/8
11/30	Santa Anita	Grace	LA12/6 SF12/8 PS12/13
LA LIBERTAD			
11/16	Byfjord	UFruit	Cr 11/19
LA UNION			
11/15	Byfjord	UFruit	Cr 11/19
LIMON			
11/15	Candida	UFruit	Ho11/26 NO11/29
11/21	Loviand	UFruit	NY11/29
11/29	Marna	UFruit	Ho12/10 NO12/12
12/5	Choluteca	UFruit	NY12/13
12/13	Candida	UFruit	Ho12/24 NO12/26
12/19	Loviand	UFruit	NY12/27
LOBITO			
11/17	Afr Pilot	Farrell	NY12/12

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SAILS	SHIP	LINE	DUE
12/4	Afr Dawn	Farrell	NY12/29
12/17	Afr Glen	Farrell	NY1/12

LUANDA

11/15	Afr Pilot	Farrell	NY12/12
11/22	Del Campo	Delta	NO12/22
11/30	Afr Dawn	Farrell	NY12/27
12/13	Del Monte	Delta	NO1/12
12/15	Afr Glen	Farrell	NY1/12
1/3	Del Sol	Delta	NO2/2
1/4	Afr Pilgrim	Farrell	NY1/30
1/17	Afr Grove	Farrell	NY2/12
1/29	Afr Pilot	Farrell	NY2/25

MATADI

11/15	Hartvig	Maersk	NY12/24 LA1/22 SF1/24
11/15	Afr Pilot	Farrell	NY12/12
11/19	Lubilash	B-Afr	NY12/5
11/19	Del Campo	Delta	NO12/22
12/3	Afr Dawn	Farrell	NY12/27
12/10	Del Monte	Delta	NO1/12
12/10	Afr Glen	Farrell	NY1/12
12/14	Kirsten	Maersk	NY1/24 LA2/22 SF2/24
12/31	Del Sol	Delta	NO2/2
1/6	Afr Pilgrim	Farrell	NY1/30
1/12	Afr Grove	Farrell	NY2/12
2/1	Afr Pilot	Farrell	NY2/25

MOMBASA

11/10	Afr Glade	Nedlloyd	NY1/1 LA1/20 SF1/24 Po1/31 Se2/4 Va2/7
12/4	Rondo	Farrell	Bo1/10 NY1/12
12/14	Afr Lightning	Farrell	Bo1/26 NY1/27
12/28	Afr Rainbow	Nedlloyd	NY2/2 LA2/21 SF2/25 Po3/4 Se3/8 Va3/11
1/5	Friesland	Farrell	Bo12/7 NY12/9
1/27	Afr Moon	Farrell	Bo2/23 NY2/25
1/30	Samarinda	Nedlloyd	NY2/27 LA3/18 SF3/22 Po3/29 Se4/2 Va4/5

SAILS	SHIP	LINE	DUE

NICARAGUA

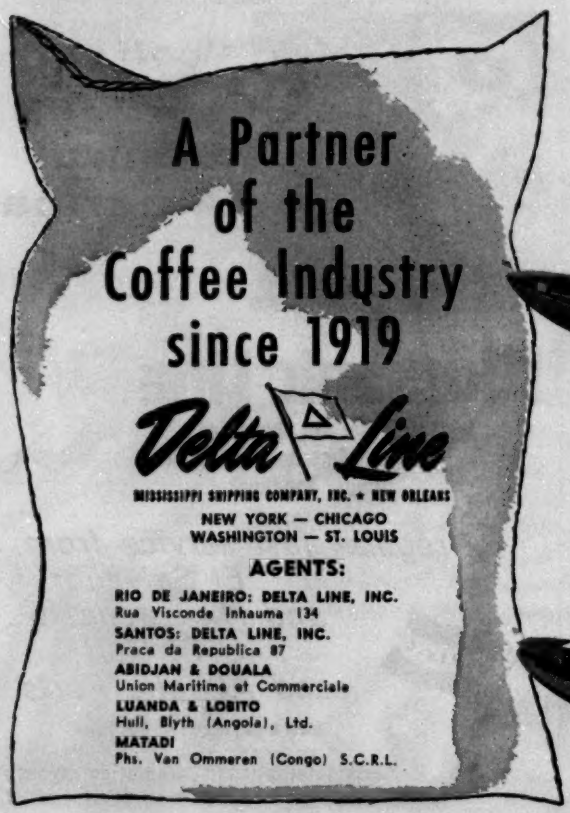
11/12	Santa Cruz	Grace	LA11/25 SF11/26 PS11/30
11/28	Santa Anita	Grace	LA12/6 SF12/8 PS12/13

PARANAGUA

11/10	Del Viento	Delta	NO12/1 Ho12/6
11/12	Alpherat	Hol-Int	NY12/2 Bo12/4 HR12/6 Ba12/12 Pa12/13
11/12	Domingos	Lloyd	NY12/2
11/16	Mormachawk	Mormac	NY12/3 Bo12/8 Pa12/10 Ba12/12 Nf12/13
11/17	Trader	Nopal	NO12/4 Ho12/7
11/17	Del Mar	Delta	NO12/3 Ho12/8
11/18	Mormacdawn	Mormac	LA12/16 SF12/19 Va12/23 Se12/30 Po1/2
11/21	Chile	Lloyd	NO12/12 Ho12/19
11/21	Svenksund	Norton	NY12/13 Bo12/17 Pa12/19 Ba12/20
11/22	Brasil	Lloyd	NY12/12
11/22	Del Mundo	Delta	NO12/15 Ho12/20
11/24	Mormocsea	Mormac	Jx12/12 NY12/16 Bo12/19 Pa12/21 Ba12/23
11/26	Alphacca	Hol-Int	NY12/16 Bo12/18 HR12/21 Ba12/26 Pa12/30
11/29	Mormacmar	Mormac	LA12/30 SF1/2 Va1/7 Se1/13 Po1/16
11/29	Evanger	Wes-Lar	LA1/2 SF1/4 Po1/11 Se1/13 Va1/14
11/30	Mormactide	Mormac	Ba12/20 Pa12/22 NY12/23 Bo12/27 Ha12/28
12/1	Del Norte	Delta	NO12/17 Ho12/22
12/3	Mormacsaga	Mormac	NY12/23 Bo12/26 Pa12/28 Ba12/30 Nf12/31
12/4	Progress	Nopal	NO12/21 Ho12/24
12/6	Del Rio	Delta	NO12/28 Ho1/3
12/7	Mormacyork	Mormac	Ja12/28 Ba1/2 Pa1/4 NY1/5 Bo1/7 Ha1/9
12/12	Mormacland	Mormac	LA1/13 SF1/16 Va1/20 Se1/27 Po1/30
12/14	Mormacteal	Mormac	Ba1/5 Pa1/7 NY1/8 Bo1/11
12/15	Del Sud	Delta	NO1/31 Ho1/3
12/20	Del Aires	Delta	NO1/13 Ho1/17
12/20	Mormacwren	Mormac	NY1/8 Bo1/11 Pa1/12 Ba1/14 Nf1/15
12/29	Del Santos	Delta	NO1/20 Ho1/24

RIO de JANEIRO

11/14	Del Viento	Delta	NO12/1 Ho12/6
11/17	Alpherat	Hol-Int	NY12/2 Bo12/4 HR12/6 Ba12/12 Pa12/13



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AND LIBERIA
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SAILS	SHIP	LINE	DUE
11/17	Mormacdawn	Mormac	LA12/16 SF12/19 Va12/23 Se12/30 Po1/2
11/17	Hardanger	Wes-Lar	LA12/13 SF12/15 Po12/22 Se12/24 Va12/25
11/17	Domingos	Lloyd	NY12/2
11/20	Del Mar	Delta	NO12/3 Ho12/8
11/21	Trader	Nopal	NO12/4 Ho12/7
11/26	Chile	Lloyd	NO12/12 Ho12/19
11/27	Brasil	Lloyd	NY12/12
11/27	Mormacmar	Mormac	LA12/30 SF1/2 Va1/7 Se1/13 Po1/16
11/28	Del Mundo	Delta	NO12/15 Ho12/20
11/28	Mormacsea	Mormac	Jx12/12 Be12/19 Pa12/21 Ba12/23
12/1	Alphacca	Hol-Int	NY12/16 Be12/18 HR12/21 Ba12/26 Pa12/30
12/4	Del Norte	Delta	NO12/17 Ho12/22
12/5	Mormactide	Mormac	Ba12/20 Pa12/22 NY12/23 Ba12/26 Be12/28
12/8	Evanger	Wes-Lar	LA1/2 SF1/4 Po1/11 Se1/13 Va1/14
12/8	Progress	Nopal	NO12/21 Ho12/24
12/8	Mormacland	Mormac	LA1/13 SF1/16 Va1/20 Se1/27 Po1/30
12/9	Mormacsaga	Mormac	NY12/23 Be12/26 Pa12/28 Ba12/30 Nf12/31
12/12	Brasil	Mormac	NY12/23
12/12	Del Rio	Delta	NO12/29 Ho1/3
12/18	Del Sud	Delta	NO1/31 Ho1/5
12/21	Mormacteal	Mormac	Ba1/5 Pa1/7 NY1/8 Be1/11
12/27	Del Aires	Delta	NO1/13 Ho1/17
1/3	Del Santos	Delta	NO1/20 Ho1/24

SANTOS

11/10	Doretea	Norton	NY11/28 Be12/2 Pa12/4 Ba12/5
11/12	Del Viento	Delta	NO12/1 Ho12/6
11/12	Hardanger	Wes-Lar	LA12/13 SF12/15 Po12/22 Se12/24 Va12/25
11/13	Mormacmail	Mormac	Jx11/28 Ba12/2 Pa12/4 NY12/5 Be12/8 Ha12/9
11/15	Alpherat	Hol-Int	NY12/2 Be12/4 HR12/6 Ba12/12 Pa12/13
11/16	Domingos	Lloyd	NY12/2
11/19	Del Mar	Delta	NO12/3 Ho12/8
11/19	Trader	Nopal	NO12/4 Ho12/7
11/20	Mormachawk	Mormac	NY12/5 Be12/8 Pa12/10 Ba12/12 Nf12/13
11/20	Mormacdawn	Mormac	LA12/16 SF12/19 Va12/23 Se12/30 Po1/2
11/24	Svenskasund	Norton	NY12/13 Be12/17 Pa12/19 Ba12/20
11/25	Chile	Lloyd	NO12/12 Ho12/19
11/26	Brasil	Lloyd	NY12/12
11/26	Del Mundo	Delta	NO12/15 Ho12/20
11/27	Mormacsea	Mormac	Jx12/12 NY12/16 Be12/19 Pa12/21 Ba12/23
11/29	Alphacca	Hol-Int	NY12/16 Be12/18 HR12/21 Ba12/26 Pa12/30
12/3	Mormacmar	Mormac	LA12/30 SF1/2 Va1/7 Se1/13 Po1/16
12/3	Del Norte	Delta	NO12/17 Ho12/22
12/4	Mormactide	Mormac	Ba12/20 Pa12/22 NY12/23 Be12/27 Ha12/28
12/5	Evanger	Wes-Lar	LA1/2 SF1/4 Po1/11 Se1/13 Va1/14
12/6	Progress	Nopal	NO12/21 Ho12/24
12/8	Mormacsaga	Mormac	NY12/23 Be12/26 Pa12/28 Ba12/30 Nf12/31
12/10	Del Rio	Delta	NO12/29 Ho1/3
12/11	Brasil	Mormac	NY12/23
12/13	Mormacyork	Mormac	Jx12/28 Ba1/2 Pa1/4 NY1/5 Be1/7 Ha1/9
12/17	Mormacland	Mormac	LA1/13 SF1/16 Va1/20 Se1/27 Po1/30
12/17	Del Sud	Delta	NO12/31 Ho1/5
12/20	Mormacteal	Mormac	Ba1/5 Pa1/7 NY1/8 Be1/11
12/24	Mormacwren	Mormac	NY1/8 Be1/11 Pa1/12 Ba1/14 Nf1/15
12/24	Del Aires	Delta	NO1/13 Ho1/17
12/31	Del Santos	Delta	NO1/20 Ho1/24

TANGA

11/29	Afr Lightning	Farrell	Be1/10 NY1/12
11/30	Rondo	Nedlloyd	NY1/1 LA1/20 SF1/24 Po1/31 Se2/4 Va2/7
1/1	Afr Rainbow	Farrell	Be1/26 NY1/27
1/1	Friesland	Nedlloyd	NY2/2 LA2/21 SF2/25 Po3/4 Se3/8 Va3/11
1/26	Samarinda	Nedlloyd	NY2/27 LA3/18 SF3/22 Po3/29 Se4/2 Va4/5
1/28	Afr Moon	Farrell	Be2/23 NY2/29

VICTORIA

11/16	Del Viento	Delta	NO12/1 Ho12/6
11/27	Chile	Lloyd	NO12/12 Ho12/19
11/30	Del Mundo	Delta	NO12/15 Ho12/20
12/14	Del Rio	Delta	NO12/29 Ho1/3
12/29	Del Aires	Delta	NO1/13 Ho1/17
1/5	Del Santos	Delta	NO1/20 Ho1/24

[3] Accepts freight for Atlantic and Gulf ports, with transshipment at Cristobal, C.Z.

TEA BERTHS

CALCUTTA

11/10	Explorer	Am-Exp	Be12/17 NY12/19 Pa12/23 HR12/25 Ma12/27
11/10	Steel Vendor	Isthmian	NO12/17
11/15	Steel Recorder	Isthmian	NY12/21 NO12/29

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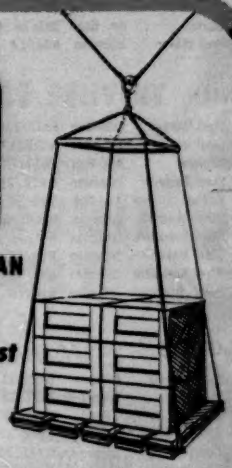

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NEW ORLEANS
Queen & Crescent Bldg.

SAILS	SHIP	LINE	DUE
11/21	Express	Am-Exp	Bo1/16 NY1/18 Pa1/22 HR1/24 Ba1/26
12/9	Steel Maker	Isthmian	NO1/17

COCHIN

11/15	Steel Worker	Isthmian	Ba12/11 NY12/12
11/16	Steel Vendor	Isthmian	NO12/17
11/21	Explorer	Am-Exp	Bo12/17 NY12/19 Pa12/23 HR12/25 Ba12/27
11/21	Steel Recorder	Isthmian	NY12/21 NO12/29
11/29	Express	Am-Exp	Bo1/16 NY1/18 Pa1/22 HR1/24 Ba1/26
11/29	Steel Chemist	Isthmian	Ba12/26 NY12/27
12/15	Steel Executive	Isthmian	Ba1/11 NY1/12
12/15	Steel Maker	Isthmian	NO1/17
12/30	Steel Navigator	Isthmian	Bo1/26 NY1/27
1/16	Steel Scientist	Isthmian	Bo2/13 NY2/14

COLOMBO

11/12	Steel Worker	Isthmian	Bo12/11 NY12/12
11/14	Matra	Cunard	Bo12/15 NY12/17 Pa12/20 Nf12/22 Ba12/25
11/14	Masirah	Cunard	Sa12/13 NO12/18 Ha12/21 Ga12/23
11/15	Steel Vendor	Isthmian	NO12/17
11/19	Fernbay	Barb-Frn	NY12/16 Bo12/21 Ba12/24 Gulf 12/29
11/20	Steel Recorder	Isthmian	NY12/21 NO12/29
11/21	Hulda	Maersk	Ha12/17 NY12/20
11/26	Steel Chemist	Isthmian	Ba12/26 NY12/27
12/3	Fernstate	Barb-Frn	NY12/29 Ba1/4 Ba1/7 Gulf 1/12
12/7	Anna	Maersk	NY1/6 Ha1/20
12/12	Steel Executive	Isthmian	Ba1/11 NY1/12
12/14	Steel Maker	Isthmian	NO1/17
12/19	Glenville	Barb-Frn	NY1/14 Bo1/19 Ba1/22 Gulf 1/27
12/21	Peter	Maersk	Ma1/15 NY1/18
12/27	Steel Navigator	Isthmian	Ba1/26 NY1/27
1/2	Oakville	Barb-Frn	NY1/27 Bo2/2 Ba2/5 Gulf 2/10
1/7	Lica	Maersk	NY2/3 Ha2/18
1/9	Francisville	Barb-Frn	NY2/14 Bo2/19 Ba2/22 Guld 2/27
1/13	Steel Scientist	Isthmian	Bo2/13 NY2/14
1/21	Olga	Maersk	Ha2/15 NY2/18

SAILS	SHIP	LINE	DUE

DJAKARTA

11/10	Steel Chemist	Isthmian	Bo12/26 NY12/27
11/12	Fernstate	Barb-Frn	NY12/29 Bo1/4 Ba1/7 Gulf 1/12
11/18	Anna	Maersk	NY1/6 Ha1/20
11/27	Steel Executive	Isthmian	Ba1/11 NY1/12
11/28	Glenville	Barb-Frn	NY1/14 Bo1/19 Ba1/22 Gulf 1/27
12/11	Steel Navigator	Isthmian	Bo1/26 NY1/27
12/12	Oakville	Barb-Frn	NY1/27 Bo2/2 Ba2/5 Gulf 2/10
12/18	Lica	Maersk	NY2/3 Ha2/18
12/28	Steel Scientist	Isthmian	Bo2/13 NY2/14
12/28	Francisville	Barb-Frn	NY2/14 Bo2/19 Ba2/22 Gulf 2/27

DJIBOUTI

11/21	Matra	Cunard	Bo1/15 NY12/17 Pa12/20 Nf12/22 Ba12/25
11/22	Steel Worker	Isthmian	Ba12/11 NY12/12
11/28	Explorer	Am-Exp	Bo12/17 NY12/19 Pa12/23 HR12/25 Ba12/27
12/2	Steel Recorder	Isthmian	NY12/21 NO12/29
12/7	Steel Chemist	Isthmian	Ba12/26 NY12/27
12/9	Express	Am-Exp	Bo1/16 NY1/18 Pa1/22 HR1/24 Ba1/26
12/22	Steel Executive	Isthmian	Ba1/11 NY1/12
1/7	Steel Navigator	Isthmian	Bo1/26 NY1/27
1/24	Steel Scientist	Isthmian	Bo2/13 NY2/14

HONG KONG

11/18	Maren	Maersk	LA12/12 NY12/27
11/19	Tancred	Barb-Wn	SF12/12 LA12/14 NY12/29
11/21	Japan Bear	PacFar	SF12/7 LA12/12
12/3	Rita	Maersk	SF12/25 NY1/11
12/4	Queensville	Barb-Wn	SF12/27 LA12/29 NY1/13
12/18	Effie	Maersk	LA1/12 NY1/27
12/19	Troubadour	Barb-Wn	SF1/11 LA1/13 NY1/28
12/21	Korean Bear	PacFar	SF1/5 LA1/11
1/3	Chastine	Maersk	SF1/26 NY2/12
1/4	Fernbank	Barb-Wn	SF1/27 LA1/29 NY2/13
1/18	Nicoline	Maersk	LA2/12 NY2/27
1/19	Turandot	Barb-Wn	SF2/11 LA2/13 NY2/28

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SAILS	SHIP	LINE	DUE
KOBE			
11/10	Toreador	Barb-Wn	SF11/27 LA11/29 NY12/14
11/14	Ming	Pioneer	NY12/9 Ba12/13 Nf12/15 Pa12/17
11/24	Maren	Maersk	LA12/12 NY12/27
11/25	Tancred	Barb-Wn	SF12/12 LA12/14 NY12/29
12/9	Rita	Maersk	SF12/25 NY1/11
12/10	Queensville	Barb-Wn	SF12/27 LA12/29 NY1/13
12/25	Troubadour	Barb-Wn	SF1/11 LA1/13 NY1/28
12/25	Effie	Maersk	LA1/12 NY1/27
1/9	Chastine	Maersk	SF1/26 NY2/12
1/10	Fernbank	Barb-Wn	SF1/27 LA1/29 NY2/13
1/25	Turandot	Barb-Wn	SF2/11 LA2/13 NY2/28
1/25	Nicoline	Maersk	LA2/12 NY2/27
SHIMIZU			
11/11	Susan	Maersk	SF11/25 NY12/12
11/13	Toreador	Barb-Wn	SF11/27 LA11/29 NY12/14
11/16	Ming	Pioneer	NY12/9 Ba12/13 Nf12/15 Pa12/17
11/26	Maren	Maersk	LA12/12 NY12/27
11/28	Tancred	Barb-Wn	SF12/12 LA12/14 NY12/29
12/11	Rita	Maersk	SF12/25 NY1/11
12/13	Queensville	Barb-Wn	SF12/27 LA12/29 NY1/13
12/27	Effie	Maersk	LA1/12 NY1/27
12/28	Troubador	Barb-Wn	SF1/11 LA1/13 NY1/28
1/11	Chastine	Maersk	SF1/26 NY2/12
1/13	Fernbank	Barb-Wn	SF1/27 LA1/29 NY2/13
1/27	Nicoline	Maersk	LA2/12 NY2/27
1/28	Turandot	Barb-Wn	SF2/11 LA2/13 NY2/28
YOKOHAMA			
11/15	Susan	Maersk	SF11/25 NY12/12
11/15	Toreador	Barb-Wn	SF11/27 LA11/29 NY12/14
11/18	Ming	Pioneer	NY12/9 Ba12/13 Nf12/15 Pa12/17
11/30	Tancred	Barb-Wn	SF12/12 LA12/14 NY12/29
11/30	Maren	Maersk	LA12/12 NY12/27
12/15	Queensville	Barb-Wn	SF12/27 LA12/29 NY12/14
12/15	Rita	Maersk	SF12/25 NY1/11
12/30	Troubadour	Barb-Wn	SF1/11 LA1/13 NY1/28
12/31	Effie	Maersk	LA1/12 NY1/27
1/15	Chastine	Maersk	SF1/26 NY2/12
1/15	Fernbank	Barb-Wn	SF1/27 LA1/29 NY2/13
1/30	Turandot	Barb-Wn	SF2/11 LA2/13 NY2/28
1/31	Nicoline	Maersk	LA2/12 NY2/27

Study of instant coffee plant for Angola continued by Junta de Exportacao do Cafe

Efforts to establish an instant coffee plant in Angola have not yet met with a response, the Junta de Exportacao do Cafe reported recently.

But, the Junta indicated, it was an opportunity that should not be missed.

"There is no doubt that the first plant which is set up on African territory, duly equipped and with modern technical assistance, coupled with a guarantee of a market for at least part of its output by some large importing country, will have a great advantage over any others," the Junta said.

"Moreover, a plant of this type, established at the site of production, could absorb all or most of the low-grade qualities, thus leaving the very best grades for export. This should increase the prestige which our coffees have justly earned and deserve in the various markets."

Soluble plant for Guatemala to go into production soon

Industria de Café S. A. [INCASA] a $17,000,000, soluble coffee plant, 90% of whose output will be exported, is scheduled to go into production in Guatemala shortly.

Grace & Co. Central America will distribute the product in Guatemala.

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UNITED FRUIT COMPANY
Steamship Service
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and
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NEW YORK:
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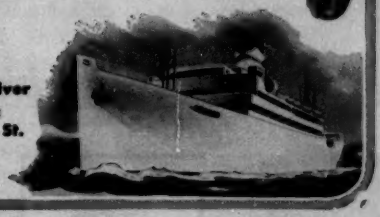
NEW ORLEANS:
321 St. Charles St.



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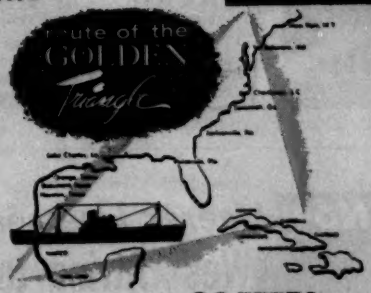
Cafe Suave
on the



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Coffee Movement In The U. S. Market

(Figures in 1,000 bags)

	Total Entries	Deliveries—from: Brazil	Others	Total	Visible Supply—1st of Month Brazil	Others	Total
		1956					
December	1,241	735	651	1,386	903	703	1,606
		1957					
January	1,749	917	809	1,726	1,064	655	1,719
February	2,026	906	927	1,833	1,362	611	1,973
March	1,956	1,224	1,060	2,284	1,233	668	1,901
April	1,209	500	528	1,028	729	547	1,276
May	1,431	546	906	1,452	759	663	1,422
June	1,301	544	792	1,336	732	606	1,338
July	1,122	563	550	1,113	545	635	1,180
August	1,588	571	1,044	1,615	599	675	1,274
September	1,290	634	579	1,213	667	645	1,312
October	1,394	721	884	1,605	704	769	1,473
November	1,801	654	962	1,616	650	590	1,240
December	1,790	963	885	1,848	610	1,075	1,685
		1958					
January	1,874	674	1,093	1,767	561	723	1,284
February	1,062	281	874	1,155	718	625	1,343
March	1,436	510	1,078	1,588	605	643	1,248
April	1,548	578	923	1,501	615	496	1,111
May	2,010	688	1,162	1,850	768	513	1,281
June	1,654	480	821	1,301	1,007	533	1,540
July	1,253	462	1,056	1,518	779	609	1,388
August	1,114	419	709	1,128	671	433	1,104
September	1,160	668	509	1,177	822	356	1,178
October	2,106	707	1,481	2,188	654	470	1,124

Figures by N. Y. Coffee & Sugar Exchange, Inc., in bags of origin. (Preliminary)

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ABIDJAN
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DOUALA: Société Navale Delmas-Veilleux, P. O. Box 263, Douala, Cameroons.

ABIDJAN: Société Navale Delmas-Vieljeux, 17, Avenue Louis Barthe, P. O. Box 1281, Abidjan, Ivory Coast.

FREETOWN: J. P. Holman's Successor Ltd., P. O. Box 130, Freetown, Sierra Leone.

Editorials

Favorable climate

People in coffee, at least the ones who told us how they feel about it, like the ideas suggested on this page last month.

We pointed out that world coffee was entering a new period. With the pact on export quotas by the 15 Latin American producing countries, the air had been cleared.

Now, for all to see with more or less undivided attention, there loomed the great problem imposed by the surplus: *how to sell more coffee.*

We suggested that the immensity of the problem calls for a new boldness in coffee promotion, that old methods may no longer be enough.

We said that one of the bold new ways to meet the immensity of the need to sell more coffee, in the United States, is a thing that's for free: the way in which we work among ourselves to plan and carry through a promotion.

This meant industry-level promotion which has roaster participation from the start, and all the way through.

Coffee men, those who commented, like this idea of joint promotion. Among these men, incidentally, are producer representatives, as well as members of the U. S. trade.

Some of their comments should be noted here. They add another dimension to thinking on joint promotion.

This is a particularly good time, these coffee men say, to take a serious look at joint promotion. Relations between producers and the U. S. trade are especially warm now.

This was not as true, they point out, before the January, 1958, convention of the National Coffee Association at Boca Raton, Florida.

Before then, the stand of the U. S. trade and of the producers on international coffee agreement was in direct conflict. Resentment was inevitable.

At the 1958 NCA convention, the U. S. trade began to approach coffee surpluses with a new realism and a new sense of statesmanship. The result was a far more flexible attitude on international agreement.

Producer attitudes have changed accordingly. Instead of resentment, there is a new cordiality.

This makes for a favorable climate in which to hold talks on joint promotion. Instead of the tensions of opposing views on surpluses, there is mutual understanding. Instead of resentment, there is common recognition of a common need: to sell more coffee.

One of the coffee men suggested we state again this paragraph from last month's editorial:

"A unified campaign multiplies its weight in some sort of geometrical progression. Five-and-five becomes more like 25 than 10."

Comment was almost as emphatic on another suggestion made on this page last month, about something that is not for free: money.

This was the thought that 25¢ a bag for coffee promotion here, rather than 10¢, is long overdue.

Some of the remarks on this were almost bitter. One man pointed out that coffee has fallen behind not simply by standing still, while other beverages put more money into their promotions. Coffee's industry-level promotion money comes from the Pan-American Coffee Bureau member countries. When they send less coffee to the U. S., their contributions for promotion drop, too.

Any advertising dollar buys less impact today than it did last year, or the year before. Costs have risen. Even if coffee had, now, the same amount of money as in peak volume years, we could buy less advertising time and space.

But we don't have the same amount of money. We have less.

Yet competition for the consumer's favor hasn't eased. On the contrary, it has become much fiercer. Promotion that doesn't step up accordingly cannot hold its own. It loses ground.

These are fundamentals that apply to any product, even coffee's competition. But coffee has its own urgency, which alone and by itself would make more promotion overwhelmingly sensible. Coffee has its surpluses.

The final paragraph in last month's editorial sharpened curiosity in a number of offices.

"Considering the cost of withdrawing and carrying surplus stocks," we said, "each promotion dollar which is effective is a cheap dollar, indeed."

How much *does* it cost a producing country to take coffee off the market and to store it?

Specific answers, it was felt, could be helpful. The figures could give producers perspective on promotion money they may not have now.

A promotion dollar that takes coffee into consumption does many things. It lessens, by that quantity of coffee, the burden of withdrawal. It brings money back into the producing country. It also builds the market for the product.

In a time of surplus, it sells coffee. As far as it can go, that is the soundest answer of all.

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since 1846

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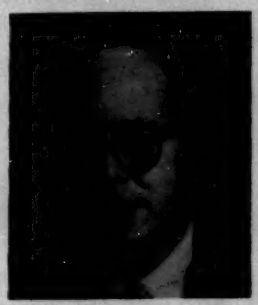
MEMBER: TEA ASSOCIATION OF U.S.A.

see Tea Center as "big stride" for industry; plans announced at Whiteface Inn convention

P. C. Irwin, Jr., elected president; Nielsen researchers see upturn in consumer tea buying; Schensul calls for shift in restaurant emphasis to hot tea service; Gertenbach shows trade its own talent

The United States will have a Tea Center next year, to serve as the focal point for the industry's promotion activities.

Formal announcement was made at the 13th annual convention of the Tea Association of the U.S.A., held at Whiteface Inn, on Lake Placid, at Whiteface, N. Y.



P. C. Irwin, Jr.

Robert B. Smallwood, chairman of the Tea Council of the U.S.A., Inc., and board chairman of Thomas J. Lipton, Inc., said, "The Tea Center represents the largest single stride forward by the industry since the inception of the Tea Council."

"Tea's Home" was the theme of the convention.

The Tea Center is scheduled to open in the fall of 1959. It will be located in New York City, in the modern five-story building at 16 East 56th Street.

The convention set a postwar precedent with the election of an importer as president. He is P. C. Irwin, Jr., of Irwin-Harrisons-Whitney, Inc., New York City.

He succeeds Edward C. Parker, of the Tetley Tea Co., Inc., New York City.

Phillip I. Eisenmenger, of Standard Brands Inc., was named vice president, and Joseph F. Diziki, of the Carter, Macy Co., Inc., was elected treasurer.

New members of the board of directors are W. G. Barker, Thomas J. Lipton, Inc.; A. W. Dimes, Tetley Tea Co., Inc.; and William H. Hall, McCormack & Co., Inc. Reelected to the board were H. W. Chapman and Mr. Irwin.

Under the chairmanship of Thomas J. O'Rourke, of the Aldine Paper Co., the convention continued—and even deepened—its tradition as the industry's focal point for fun and relaxation.

After last year's Circus Night, this seemed impossible. But Hollywood Night at Whiteface Inn was packed with such hilarity that, at times, it almost hurt.

One of the reasons was the emergence of remarkable talent within the tea trade itself.

Robert F. Gertenbach, incoming chairman of the Junior Board of Directors of the Tea Associaiton, revealed himself as a skillful master of ceremonies and a delightful wag.

He brought to Hollywood Night, already gay with tea people in fancy-free costumes, an unsuspected reservoir of skits and an astonishing personal ability as a comedian—in words and otherwise.

He also uncovered a faculty for tapping the talents of other tea people, talents which some of them did not know they had.

Assisting Mr. Gertenbach were other Junior members, including Thomas E. Dannemiller, outgoing Junior Board chairman, Norman Langer and William Hall, now elected to the Senior Board. Drafted for what turned out to be one of delicious performances of the evening was C. William

Looking over plans for the Tea Center are (from left) Robert B. Smallwood, Tea Council chairman; William Decker, president of the Corning Glass Works, which is leasing the building to the Tea Council; and Edward C. Parker, outgoing president of the Tea Association. Tea Center model is on the table.

Felton, who points out that any resemblance between his role that night and reality is entirely without foundation.

Mrs. Hall and Mrs. Langer also pitched in, with competent and understanding performances.

From the reaction of the audience to "The Tea Bag Players," nursed by Mr. Gertenbach to their debut that night, overwhelming demand for another presentation at the next convention is inevitable.

Tapped for stage bits in another Gertenbach skit were ladies from the audiences, picked with a discrimination which spoke highly for the keenness of Junior Board and C. W. Felton eyes in the rather dimly lit room.

It was a Gertenbach evening, easily the most mirthful entertainment to come before any tea convention.

The 1958 convention saw another entertainment high point—Mr. Felton in his traditional "Alouette," but given with a sweep and timing which marked it as his best yet.

Weather

On Monday, official opening day of the convention, the Adirondacks produced a bright, sparkling sample of northern New York autumn at its best. The weather that went before, and after, tended toward cloudiness and even some rain, but not before the golfers had plenty of opportunity to take the measure of the whiteface course.

The Tea Center will provide facilities for food industry exhibits and seminars, product and cultural displays from tea producing nations—India, Ceylon and Indonesia—and demonstrations and films for educational and social groups and clubs, the conventioneers learned.

"In broad terms, the Tea Center will be a new, major tool for the promotion of tea in the United States," Mr. Smallwood explained. "It will be a new institution for increasing the importance of tea in the minds of people."

Turning to industry trends, Mr. Smallwood declared that tea in the United States is in the healthiest position it has ever enjoyed. He cited annual consumption of more than 30,000,000,000 cups of the beverage.

Tea in food stores

"In terms of grocery store volume alone," he continued, "sales this year are running 2% ahead of 1957, and 20% above 1951, when the first tea industry program started. In the institutional field, too, sales are on the upswing."

Preliminary planning for the Tea Center got under way about a year ago, when the need for a centralized base of operation became apparent.

"Commensurate with the gain in consumption," Mr. Smallwood said, "is the demand for more product information from both the merchant and the consumer. The merchant continuously seeks more and better ways to sell tea, while the consumer constantly seeks more and better ways to serve tea.

"With the Center, we will be able to meet these demands and, at the same time, increase the stature and prestige of an industry which has matured beyond its growing pains."

The Tea Center building was obtained under a long-term lease from the Corning Glass Works.

At a convention session devoted to tea's new home, Mr. Felton told about the physical set-up of the building and plans for complete remodeling and redecorating to meet tea industry requirements.

Mr. Felton, president of Henry P. Thomson, Inc., is chairman of the Tea Center Committee.

The first and second floors of the building will be devoted to Tea Center activities. A major feature of this area will be an auditorium providing facilities for the showing of films and demonstrations. In addition, there will be rooms to house rotating exhibits.

The staffs of the Tea Association and the Tea Council will occupy the third and fourth floors, moving from their present location at 500 Fifth Ave., New York City.

The fifth floor will be used for receptions and entertainment of distinguished visitors, such as industry leaders, government officials and dignitaries from tea producing countries.

The Tea Center Committee, which has members who are a cross-section of the United States tea trade, is inviting companies to contribute to a fund for the furnishing of the public rooms.

Fred Rosen, of Fred Rosen Associates, Inc., publicity counsel to the Tea Council, said the Tea Center will give the industry's campaign in this country its greatest opportunity "to use the most effective sales technique of all—*word of mouth recommendation.*"

Opinion leaders

The aim would be to get the opinion leaders into the Tea Center, and to educate them about tea, he declared. He said there were 50,000 opinion leaders who because of jobs, social prestige or leadership positions have the power to shape opinions of large numbers of people about ideas or products.

They include, he added, people in the mass media—newspapers, television, radio, magazines.

"The Food Editors' Conference can easily have meetings of its executive committee in the Tea Center," Mr. Rosen suggested. "They have already said they would be delighted to come.

"Part of the activities of the Tea Center should be designed to interest and educate the men in industry who actually have to buy tea and sell it to the public. This, I feel, is a very important point in making Tea Center pay off.

"Finally I should like to mention another crucial segment of the 50,000 who are our constant target—the men and women of the tea industry itself, the importers, distributors, packers, executives and salesmen. To all, the Tea Center has already performed a really important service. It has been a tremendous moral stimulant, a psychological shot in the arm to the whole tea trade.

Among the general ideas under discussion for the Tea Center, reported Mr. Rosen, were these:

Tea Center seminars for small discussion groups of top people on various aspects of tea and/or food.

Press parties on tea, and for allied industries on a carefully selected basis.

Contests, with the Tea Center as a home for such events, to dramatize proper brewing methods for millions of consumers.

Social events, such as selection of a prominent personality

(*Continued on page 154*)

Tea's 1958 convention: A picture report

The new and unforgettable Bob Gertenbach in action, with ladies from the audience, during Hollywood Night at the Whiteface Inn convention. Under that top hat is Tom O'Rourke, chairman of the convention, with Mrs. O'Rourke. This picture is evidence that the indefatigable O'Rourke does, sometimes, sit at a tea convention. The roly-poly individual is Joe Diziki, well padded for the occasion. The Robin Hood and the victim with the arrow through her noggin are the Oscar Gorenflos. That bow is a real 50-pounder.

The wonders of the 13th convention on Hollywood night! The gay caballero is Edgar Pinto, the little flower girl Mrs. P. C. Irwin, Jr. Those samples out of the West are Mrs. Herman Preston and Two-Gun Reggie Sanger. The courtly pair are the William MacMelvilles, while the knobby knees in the adjoining picture belong to that old Roman, Max (Marc Antony) Margolies. His Cleopatra was far easier to look at. Proof that East is East and West is West but sometimes the twain do meet are the H. C. Lears.

Demonstrating some of the unsuspected advantages of Arabian garb are Warren Cousins and his wife, while in the background Mrs. Carl Hull flaps her fabulous eyelashes at Bill Hall. Under that awesome hat is Mrs. John Batson, with Mr. Batson, powdered wig and all, at her side. It's the Carl Hulls who are cheek-to-cheek, which also gives you a frontal view of those eyelashes. The Hollywood "grip" is Rob Compton, with Mrs. Guy Mountfort. The ballplayer is Harold Suttle—and the lady is his wife.

GET ABOARD FOR THE HOTTEST

Steamed up and ready

We've put the fire under the biggest "Take Tea and See" Week ever... and it's coming your way February 7th. Here's what we're planning:

→ **BIG TEA-V**—more than 92 million "Take Tea and See" commercials in 23 million TV homes!

→ **BIG PUBLICITY**—a determined campaign for editorial mentions and articles in newspapers and on TV!

→ **BIG MERCHANDISING**—an all-out program to set up displays in supermarkets and restaurants, right at the point of sale!

So start planning now to pick up your share of the extra profits from "Take Tea and See" Week. What are you waiting for?

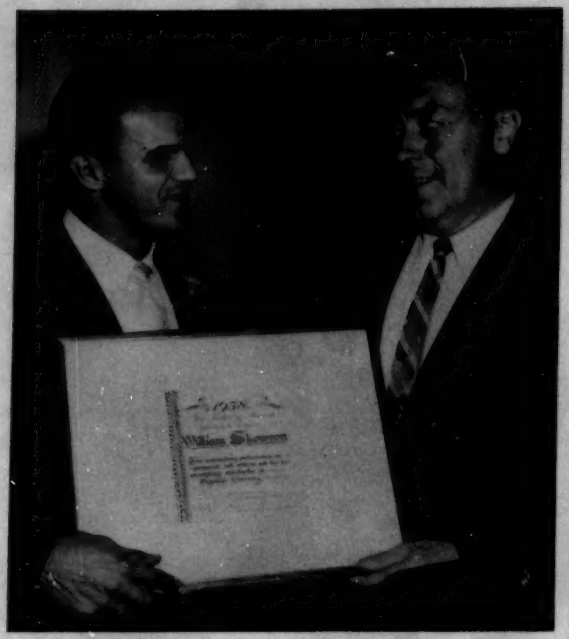
tea council

OPPORTUNITY YET FOR HOT TEA

to roll...for you!

of the U.S.A., Inc., 500 Fifth Avenue, New York 36, New York

Tea's 1958 convention: A highlight report



Bill "Moose" Skowron (left) New York Yankees' first baseman, whose three-run homer capped the 1958 World Series, accepts the tea industry's first annual award in the sporting world "for outstanding performance as sportsman and athlete and for his exemplary standards in physical training." Making the 1958 presentation is Edward C. Parker, retiring president of the Tea Association, who is a director of the Tea Council and president of the Tetley Tea Co. Sports Illustrated noted that Skowron "drinks loose tea or tea in bags that look like first-base sacks." Skowron's own comment: "Tea helps me to relax. Tea supplies a lift for athletes."

see Tea Center as "big stride"

(*Continued from page 150*)

to be honorary Tea Center hostess of the month.

Displays on tea and tea activities, for which the Tea Center will be ideal, and also on subjects of interest to the food trade.

Distinguished visitors from India, Ceylon, Indonesia and other areas of interest to tea would be received at the Center, with appropriate press coverage.

Presentations and awards, e.g., "He-Man Tea-Man of the Year," would be made at the Tea Center.

Schools and the youth market, another Tea Center target, would be reached through visits by teachers and selected classes.

"The Tea Center will be a visible symbol of the success and effectiveness of one of the most imaginative ideas of our time—the Tea Council partnership," Mr. Rosen emphasized.

"It will be a visible symbol of the fact that a group of American businessmen have joined together with people in far-away countries in a working partnership which has survived and grown through international strains and political tensions."

Consumer buying of tea is on the upgrade, Carl M. Wall, of the A. C. Nielsen Co., told the convention. After three years of virtually unchanged consumer buying of tea, 1958 sales through food stores are up 2%, he reported.

"At the present rate, 1958 sales are estimated to be almost 82,000,000 lbs., an increase of over 2,000,000 lbs. from 1956, and at least 1,500,000 lbs. over 1957," he said. "They are at a new high, aside from the peak year 1954, which was influenced by the unusually high price of coffee."

(A detailed report on Mr. Nielsen's presentation will appear in the next issue of COFFEE & TEA INDUSTRIES.)

Hector Lazo, senior professor of marketing at New York University, talked on "Tea in an Expanding Market." (See: Page 47, October, 1958, COFFEE & TEA INDUSTRIES).

Joseph Schensul, president of the National Restaurant Association, told the convention that hot tea service still presents problems to restaurant operators which have not been satisfactorily overcome.

That is why he feels a letdown on tea in the fall, when the iced tea season is on the wane, he revealed.

"Somehow I, as a restaurant operator, and in particular a cafeteria operator, never have quite the same enthusiasm for the hot tea season," Mr. Schensul declared.

He added that the Tea Council's efforts to perfect a tea urn were in recognition of the hot tea problems, and a step in the right direction.

Focus on hot tea

"Hot tea sales in restaurants have been on the rise, due mostly to customer demand created by your consumer advertising," he told the teamen." Whether or not the customer is getting the ideal brew in every instance of eating away from home is still the important question. We are inclined to believe that the 'advertising-educated' consumer 'accepts' an indifferently brewed pot of tea simply because he 'wants' tea.

"Now, of course, the progressive and sales-minded restaurant operator decries this situation. He sees to it that his customers are satisfied that they have gotten what they want. But while he will do an excellent job of serving all the hot tea his customers want, it does not follow that he will push sales if there are too many problems—pots, dishes, handling, lemon, etc.—connected with each sale.

"This type of progressive operator is, of course, most interested in methods of brewing and serving tea with the same ease as coffee. We believe this to be the ultimate answer to most of our problems. And we are sure the day will come.

"What is of concern to us, and should be to you, is the 'not-so-progressive' restaurant operator who keeps a box of tea bags on hand just in case somebody asks for it.' Unfortunately, there are far more operators of this type than of the progressive type, although even in the aggregate they do a small percentage of the total volume of business.

"They constitute almost no market for quantity brewing equipment. Mostly they are not susceptible to the pressures of advertising or education. And every time they serve a bad cup of hot tea they have done no favor either to you as the industry, or to the more progressive operators, be-

cause they have in effect discouraged the use of a product in a public eating establishment."

This does not necessarily hold to the same extent in the case of iced tea, Mr. Schensul pointed out.

"Here no great amount of equipment or time is involved," he said. "In your one-two-three method, you have made the formula almost foolproof. You have developed demand. You have educated the operator that the profit is substantial and built-in."

Mr. Schensul declared that each year more and more restaurateurs are lengthening the iced tea season, starting earlier and keeping it on the menu longer. He said tea industry sales aids are attractive, with universal operator appeal.

Joint effort

He urged more joint effort on the problem of selling more hot tea.

"Consumer advertising alone isn't going to do it," he stressed. "The problem needs research, education and advertising.

"We believe the time has come to shift the emphasis to hot tea service so that the tea can be sold in greater volume the year around, so that we can build as an industry good reputations for serving good tea, as we have good coffee."

Golfers at the convention played against a backdrop of Adirondack mountains at their peak of fall coloring. Winner of the men's kickers handicap was Philip I. Eisenmenger, with Thomas W. Hellyer and T. Wylie Kinney in second and third place.

Mrs. E. S. O'Keefe topped the field in the women's kickers handicap, trailed by Mrs. Willard C. Mackey, Jr.

In the 18-hole medal play for men, R. D. Thomson came through with low gross, while Thomas W. Kelly captured first low net, and Norman A. Langer second low net.

Carl F. Hull put his ball nearest to the pin.

In the women's 18-hole medal play, first and second low net went to Mrs. L. B. Heller and Mrs. Thomas E. Dannemiller.

In tennis, the winners were D. Mukerji and Charles H. Reeves.

Assisting Convention Chairman O'Rourke in arrangements and follow through were C. B. Delano, vice chairman of the convention committee; Frank T. Waters, golf; Carl Seeman, Jr., tennis; Max Margolies, prizes, assisted by members of the Junior Board; Miss M. Petrozelli, transportation; Mrs. E. C. Anderson in charge of the bridge tournament.

Walter T. Cusack, headed up the arrangements for the Allied Trades cocktail party, which opened the social activities on Sunday evening.

Other speakers included Calvin D. Johnson, special representative, Remington Rand Division, Sperry Rand Corp.; Henry Kearns, assistant secretary of commerce for international affairs, U. S. Department of Commerce; Brig. Gen. R. L. Scott, U.S.A.F. (ret.), formerly director of information services, U.S.A.F., and author of "God Is My Co-Pilot;" and Harrison E. Salisbury, Pulitzer Prize winning correspondent for the New York Times.

Tea's 1958 convention: A highlight report

the new hot tea advertising

By CHARLES M. DERING, Account Executive
Leo Burnett Co., Inc.

As you might suppose, we've done a good deal of research into who drinks hot tea and why they've made the switch from another hot beverage. From this research, we've learned who our best prospects are and how we can best impress them with our selling message.

We realize that our market for hot tea is not the universe —not *all* people are troubled by other hot beverage habits— so our selling messages are directed to a segment of this universe: *first* to those who recognize distressing elements in their hot beverage habits but do nothing about it; and *second,* to those who have already made the change to hot tea—we want to reconfirm their decision.

The most important reasons why people become hot tea drinkers are parental influence (children usually follow the hot beverage habit of their parents) and dissatisfaction with other hot beverage habits.

Naturally, we can't expect to do much about parental influence—except maybe to hope that tea-drinking families have more children.

But the people we *can* work on, our best prospects, are those people—one out of every three people—who are dissatisfied with the beverage they are now drinking but need to be triggered into action.

Generally, these are nice, average people, going along from day to day in a pretty set routine, like most of us. They think about their beverage habit occasionally, maybe even worry a little about it. Chances are their nerves are a little jumpy. Maybe their sleep isn't quite what it used to be. They may even feel a little guilty, too, about being trapped in a habit. Deep down, probably, they know what's behind it, they know what they should do about it, but they just haven't gotten around to it. They need a little push in the right direction.

This year, we're going to give them that push. We're going after these millions of people with a strong, persuasive campaign aimed at their specific problem. We'll talk their language and we'll make good sound sense. We'll come right out and say: "If you're one of those people, then you should switch to hot tea."

That's our theme for this year.

It's so straightforward and simple, it echos so well the question that has been in the minds of many people, that it can't help but hit home.

Last year as you remember, we developed a "Voice of Conscience" technique to get our message across on TV. This year we've taken that same technique and improved it to get our message across even faster, even stronger. As you recall, the person in the commercial sells himself through the voice of his own commercials—literally talks himself into the switch to hot tea, based on his own personal knowledge of the troubles his present hot beverage has caused him. You not only *hear* his conscience speaking to him, you *see* it as well. By using a technique like this, we can deliver a strong message without being stuffy, didactic or shaking our finger in a resentful manner. The viewers at home identify themselves with the man or woman in the commercial and then help convince themselves (if they are one of those people) that it's a good, beneficial idea to switch to hot tea.

This flap poster, in full color and 14" x 11" x 2" in size, is one of the point-of-purchase pieces made available by the Tea Council to help store managers put on their own hot tea promotions. This poster, as well as a full color shelf talker, were designed to meet specifications determined in field tests of independent and chain food stores. Packer salesmen will distribute the material.

Now let's take a look at the commercials. The first, a 20-second version, features a young man obviously dissatisfied with his present beverage. Quickly, forcefully, we drive home the theme, "You know you're one of those people."

The next film, also 20 seconds in length, features an attractive young woman in the same situation.

Our third "Voice of Conscience" commercial shows a well-dressed man in his mid-thirties.

I think you'll remember our next—and final—commercial. It's the fine "Spirit of Tea" film from last year. It carries the same basic selling message as the other commercials. But the 60-second length lets us develop further the positive

aspects of tea and include musical punctuation. This commercial has been called the true spirit of tea, a believable portrayal of the pleasures of tea. "Grown-up television," as some people have called it.

That's the theme of our hot tea advertising campaign for 1958-1959. With every-one of us behind it, this should be a potent selling force.

We believe this advertising is fair, sincere, honest and carries a memorable message.

This advertising will appear on night-time television, between 6 p.m. and 11 p.m. when that television audience is larger than at any other time, with 64% of the total U. S. television sets in use.

Advertising will appear in these 18 major markets of the country: Chicago, Los Angeles, New York, Baltimore, Boston, Detroit, Philadelphia, Pittsburgh, Washington, D. C., Cleveland, Providence, San Francisco, Portland, Seattle, Buffalo, Syracuse, New Haven, Schnectady. They represent over 50% of the total television homes in the United States.

During a four-week period, hot tea messages will reach 94% of the total TV homes at least once in these 18 markets, and 35% of the TV homes in these markets 11 or more times. This means that 26,000,000 people will be exposed to hot tea messages 11 or more times in a four-week period, but almost three times that number—approximately 71,000,000—will be exposed to our commercials one or more times in a four-week period.

These are calculations based upon a four-week period. However, your hot tea campaign will be running for 20 weeks beginning October 19th, five times this long. During this 20-week campaign, the average home in the 18 markets will receive 40 hot tea commercials. This in turn means that hot tea advertising will deliver the unbelievable number of approximately one billion home messages.

Among the millions of viewers in these homes are those people—*your potential customers*—to whom we are saying:

"If you are one of those people—then switch to hot tea."

Junior Board names committees

Standing committees for the coming year have been announced by Robert F. Gertenbach, of Thomas J. Lipton, Inc., chairman of the Junior Board of the Tea Association of the U.S.A.

On the executive committee are Mr. Gertenbach, Max Margolies, of the Tea Pack Co., secretary-treasurer of the Junior Board; William Congalton, Standard Brands, Inc.; and Bernard Sachs, Coffee & Tea Industries.

The same four also comprise the Projects Committee, with Mr. Margolies as chairman.

Mr. Sachs is chairman of the Publicity Committee, assisted by John Ryncki, Tetley Tea Co., Inc., and Robert Weiskopf, Stein, Hall & Co.

Gene Polizzano, of Henry P. Thomson, Inc., heads the Government Business Procedures Committee. Working with him are Gerald Dunphy, R. P. Thomas & Co.; and Frank F. Cho, Sembodja Corp. of N. Y.

John C. Haigh is chairman of the Nominating Committee, assisted by Mr. Polizzano, Charles P. Walter, Dodwell & Co., Ltd.; and Charles J. Gratale, Gratale Warehouses, Inc.

Mr. Gertenbach heads the Social Committee. Also on this committee are Robert W. Cruickshank, States Marine Isthmian Agency, Inc.; Bernard J. Etrie, Old Slip Warehouse, Inc.; Mr. Haigh and Mr. Margolies.

HENRY P. THOMSON, INC.

TEA IMPORTERS

89 Broad Street
Boston, Mass.

120 Wall Street
New York 5, N. Y.

605 Third Street
San Francisco, Calif.

Member: Tea Association of the U.S.A.

Tea Movement into the United States

(Figures in 1,000 pounds)

Black	June 1957	July 1957	Aug. 1957	Sept. 1957	Oct. 1957	Nov. 1957	Dec. 1957	Jan. 1958	Feb. 1958	March 1958	April 1958	May 1958	June 1958	July 1958	Aug. 1958	Sept. 1958
Ceylon	5,695	4,207	4,846	3,366	2,786	3,403	3,023	3,037	3,175	2,742	3,915	4,412	2,678	2,148	3,989	3,478
India	2,730	1,647	1,315	1,352	2,353	1,914	2,528	4,152	3,043	3,445	2,714	2,272	2,271	1,935	1,188	1,927
Formosa	142	167	373	562	502	548	365	510	309	344	311	480	362	651	607	694
Africa	227	484	228	394	265	217	273	303	257	510	358	529	526	561	380	241
Indonesia	1,067	1,113	894	1,334	1,155	1,430	1,518	1,510	1,070	1,178	1,347	1,836	1,664	1,793	787	993
Japan	3	15	28	17	99	197	198	249	96	58	21	56	29	15	61	36
Misc.	358	112	320	219	93	218	128	116	447	598	299	207	411	340	241	272
Green																
Japan	82	433	464	403	276	35	47	71	48	119	34	29	236	351	487	223
Misc.	6	13	24	73	6	17	2	1	9	7	6	...	13	1	4	45
Oolong																
Formosa	2	4	31	38	24	19	66	13	3	36	5	11	8	11	31	32
Canton	5	3	5	1	7	15	14	7	8	12	1	...	3	3	24	8
Scntd Cntn	15	3	2	2	3	6	6	5	5	8	4	3	6	7	3	4
Mixed	4	6	14	17	12	15	19		9	8	4	5	9	16	6	10
TOTALS	10,336	8,207	8,546	7,808	7,593	8,040	8,167	9,980	8,479	9,065	9,219	9,840	8,216	7,832	7,808	7,963

Figures cover teas examined and passed, do not include rejections. Based on reports from U. S. Tea Examiner.

Edward Van Wart joins Aldine sales staff

Appointment of Edward C. Van Wart as a sales and development representative for Aldine Paper Co. was announced by Harry E. Gould, president.

Mr. Van Wart's headquarters will be at 535 Fifth Avenue, New York where he joins the staff of Aldine's Industrial and Technical Specialty Paper Division.

Mr. Van Wart comes to Aldine after eight years of service with the Industrial Chemicals Division of the American Cyanamid Co. Much of this time was spent in a sales promotion program for wet strength resins as paper-making additives. This work brought him in close contact with the extensive and interesting potentials for made-to-order special papers.

1898 - 1958

1958 marks our 60th year of service

HALL & LOUDON

TEA BROKERS

91 WALL STREET NEW YORK CITY 5

IRWIN-HARRISONS-WHITNEY INC.

TEA IMPORTERS

NEW YORK • PHILADELPHIA • BOSTON • CHICAGO • SAN FRANCISCO • SHIZUOKA (JAPAN)
CALCUTTA • COCHIN (INDIA) • COLOMBO (CEYLON) • DJARKATA (JAVA) • LONDON (ENGLAND)
MEDAN (SUMATRA) • TAIPEH (FORMOSA)

"Lucky" Salada Tea Bags spearhead huge direct mail sampling promotion

One of the most extensive sampling and couponing programs ever conducted in the Boston-Providence area got underway recently as several thousand New England families received "lucky" Salada Tea Bag tags worth from $1 to $100.

The "lucky" tags are included in many of the sample packages being mailed to hundreds of thousands of Massachusetts and Rhode Island homes. The mass promotion is being conducted for the Salada Tea Division of Salada-Shirriff-Horsey, Inc., Boston, by O. E. McIntyre Inc., a leading direct mail marketing firm.

The Boston-Providence mailing follows a similar Salada direct mail promotion to millions of New York City area families earlier this month.

Each home received a package containing four Salada Tea Bags, plus a coupon worth 10¢ when redeemed at a retail store for any size package of Salada Tea or Tea Bags.

In addition, a "Golden Opportunity" certificate offers the consumer an added saving of 25¢ when the coupon is used toward the purchase of 100 Salada Tea Bags. Another feature is the inclusion of a coupon worth 7¢ toward the purchase of "junket" Danish Dessert, a new tangy-sweet dessert with fresh-berry flavor.

Thousands of the tea bag tags are clearly marked: "This Is a Lucky Salada Tea Tag." Worth from $1 to $100, they can be redeemed by sending them directly to Salada.

McIntyre's program for Salada is based on the marketing firm's extensive file of individual I.B.M. cards for 36,000,000 American families, the 70% of the population with 90% of the buying power.

In planning its direct mail promotions, McIntyre furnishes clients with detailed data, such as average income, age of family, and sex of the head of the household.

Tea radioactivity no cause for alarm "whatsoever", food and drug chief says

There is "no cause for alarm whatsoever" about radioactivity in tea, Food and Drug Commissioner George P. Larrick told a press conference last month.

"The tea we are getting today is quite safe for consumption," Mr. Larrick said.

His remarks were prompted by a report by two food and drug researchers that samples of postwar tea shipments showed an increase in radioactivity, compared to prewar samples.

Even in their report, the two research men indicated that today's tea beverage is in no way unsafe.

Their report did not reveal the origin of the postwar samples which were tested, or the types of tea.

Continental adds Darjeeling tea to line

The Continental Coffee Co., Chicago, purveyor of coffee, tea and other food products to restaurants, hotels and institutions, has announced the addition of a Darjeeling blend tea to its product line.

The Darjeeling blend is being made available in full strength, 200-to-the-pound packs. It comes handsomely packed in individual blue and gold cartons of 100 bags.

LARGE

enough to handle *all* your business

SMALL

enough to handle it *personally*

"THE COMPLETE TEA BAG PACKING SERVICE"

Tea Pack Company., Inc.

367 GREENWICH ST., NEW YORK 13, N. Y., Digby 9-0748

WE PACK YOUR TEA UNDER YOUR BRAND

Member: Tea Association of the U.S.A.

Porter named chairman of Tea Council of Canada; budget at $750,000

R. Keith Porter, of Toronto, has been named chairman of the Tea Council of Canada.

Mr. Porter, executive vice-president and general manager of Thomas J. Lipton, Ltd., succeeds Harold L. Keen, of Montreal, as chairman.

R. Keith Porter

The Tea Council of Canada's annual budget of approximately $750,000.00 was disclosed when the executive director, D. M. Langton, released the Council's fourth annual report.

The Tea Council's balance sheet shows a total expenditure of $742,110.00 for the period of July, 1957 to June, 1958. Over 90% of this total was spent on advertising.

"Advertising is the most important function of the Council, accounting for 90% of our expenditures in 1957/1958," Mr. Langton said. "Since October, 1954, when the Council's advertising first appeared —less than four years ago—there have been continual and substantial increases in advertising costs. Maintaining our advertising effectiveness and coverage in this vast country of ours, plus the combination of tremendous competition from establishments and new beverages, is the major problem.

"Advertising research and ways and means to develop a reliable method of measuring the effectiveness of our advertising, to produce the best possible, to pre-test and to guide its effective placement—special sub-committees have been formed."

Tea Council's funds are made available by members of the tea industry, as well as by the principal tea producing countries, India and Ceylon, in an international partnership.

The Tea Council's current national advertising campaign, in English and French, is carried in newspapers, television and radio. Television and weekend papers, plus Readers Digest, provide the basic media.

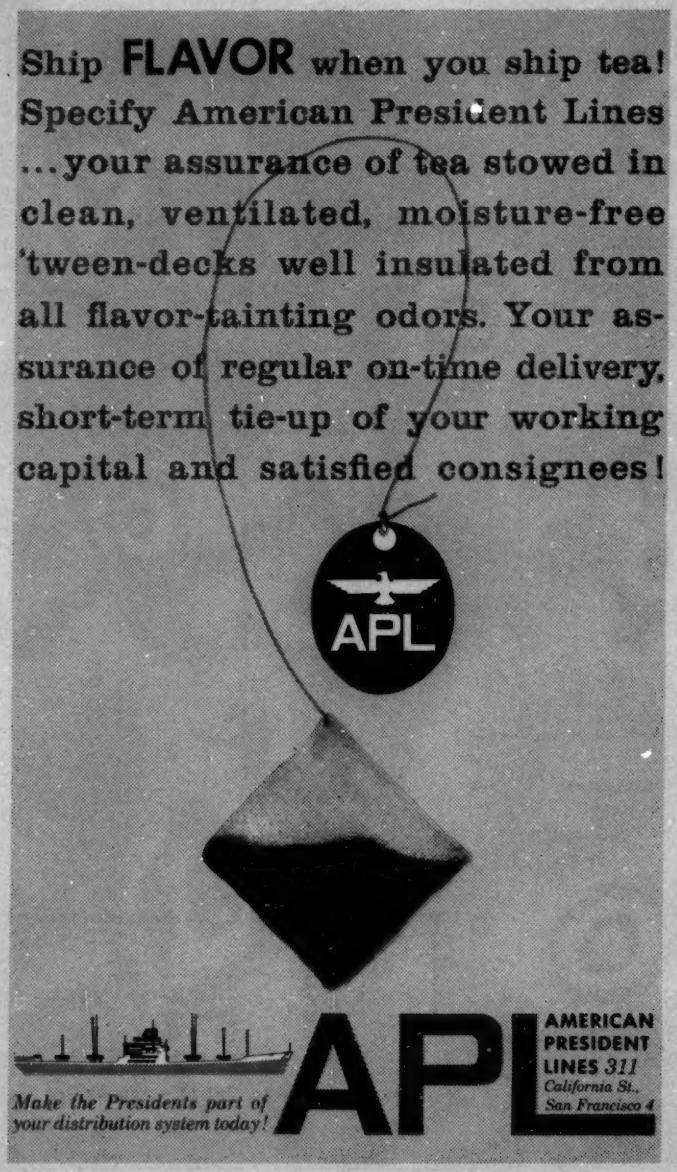
Born in Medicine Hat, Alberta, Mr. Porter obtained a Bachelor of Commerce degree from the University of British Columbia in 1942. His business career, which began with Lever Bros., Ltd., was preceded by four years in the Canadian Army.

After 1946, he held successive sales, advertising and management posts in Canada and the United States. He has been with Lipton in his present position and on the board of the Tea Council of Canada since 1954.

Plantations in India

"Plantations in India's Economy" is the subject of a booklet just issued in a revised edition by the public relations department of the United Planters' Association of Southern India.

The booklet was first published in 1955. The new edition brings the facts up-to-date.


Ship FLAVOR when you ship tea! Specify American President Lines ...your assurance of tea stowed in clean, ventilated, moisture-free 'tween-decks well insulated from all flavor-tainting odors. Your assurance of regular on-time delivery, short-term tie-up of your working capital and satisfied consignees!
APL
APL
AMERICAN PRESIDENT LINES 311 California St., San Francisco 4
Make the Presidents part of your distribution system today!

drive puts new lids on coffee cans

bag companies, too, cooperate in better brew campaign

The campaign to bring back the properly brewed cup of coffee, spearheaded by the National Coffee Association, is getting a major assist from coffee container manufacturers.

The American Can Co., developer of the vacuum coffee can, has offered coffee roasters a new, lithographed can top imprinted with instructions on the proper way to brew a perfect cup of coffee. The instructions are those officially recommended by The Coffee Brewing Institute.

The Continental Can Co. is offering metal covers for one and two pound cans, imprinted with approved directions for brewing with the particular grind packaged in the can.

The major coffee bag companies are offering to print brewing instructions on bags, free of charge. The instructions have been endorsed by the National Restaurant Association and the American Hotel Association. Their names, with that of The Coffee Brewing Institute, appear on every container so imprinted.

The message on the Canco lid contains "The Secret To Making Good Coffee." It contains instructions for all three popular brewing methods—drip, percolator and vacuum—printed in black on a plain cover.

Main part of the "Secret" is contained in a paragraph which precedes a specialized breakdown of the three methods of brewing. It tells the housewife to start with a clean coffeemaker, fresh coffee and fresh cold water, stresses the importance of careful measuring and timing, and cautions that at least three-fourths capacity of the coffeemaker should be used. It also stipulates the use of one standard coffee measure (two level measuring tablespoons) to three-fourths of a measuring cup (six ounces) of water.

The American Can Co. is sharing the cost of its special lids with the various packers.

According to Canco, the major purpose of the lid is to act as a "Kitchen Billboard"—a daily reminder to the housewife to make her coffee the right way.

Within the last ten years, Americans have become accustomed to a weak, highly diluted cup of coffee, mainly due to the fact that the housewife has forgotten how to brew a good cup, says the container company.

The result, says Canco, is that from an ideal yield of about 45 cups per pound of coffee in 1949, usage has deteriorated to a current yield of between 60 and 65 cups per pound.

Bag imprinting is not only being offered to institutional clients but also to those engaged in the retail field.

The enthusiasm generated for the brewing imprint by bag companies is best expressed in sales bulletins issued by several organizations.

The American Can Co.'s "better brew" lid for coffee cans.

The "Sales Scoop," of the Shellmar-Betner Division of the Continental Can Co., says in part:

"We have been working with The Coffee Brewing Institute for many months to come up with a program that would aid the coffee industry in its campaign to make good coffee, which means to use enough. Our company has backed paper products to the hilt ,so much so that effective immediately we are willing to print free of charge on the back panel of any coffee bag featuring front-only printing, the agreed upon copy—'The Secret of Making Good Urn Coffee.' "

In a bulletin to its sales staff the Atlantic Coffee Bag Co., Brooklyn, N. Y., puts it this way:

"It is the general feeling that the practice of extending coffee by watering is the most dangerous trend in the coffee industry today . . . We have been working with the Coffee Brewing Institute for some time to come up with a program which would aid the coffee industry in its campaign to make good coffee. To assist the Institute in its campaign, effective immediately, we are willing to print *free of charge* on the back panel of one pound bags featuring front-only printing, the Institute approved copy 'The Secret of Making Good Coffee.' "

Nestle markets "bonus" instant coffee jar; makings of ten extra cups in outsize jar

In a special promotion to make new friends for Nescafé, The Nestlé Co., Inc., is marketing a "bonus" jar with a unique, outsized neck containing enough instant coffee for ten cups. The redesigned Nescafé jar is an innovation in merchandising, retailing for the same price as the regular six ounce size.

Offered in key cities, the jar is designed to attract coffee drinkers to Nescafé through the bonus quantity rather than through the customary off-label price reduction. The special offer ties in with the company's 1958 "get acquainted" program.

Nestlé offers to refund the entire cost of the bonus jar to anyone who "does not agree that Nescafé is truly delicious coffee." In the guarantee stated on the neckband of the jar, the new user is requested to try the ten extra cups and, if dissatisfied, to return the rest of the jar for his money back.

The company reports that its expectations have been completely justified by initial merchandising reports. The bonus jar has not only increased Nescafé sales substantially but has stimulated supermarket traffic in the coffee section.

Coffee in "powdered" liquid form seen as possibility with new method

Coffee may some day be manufactured as a liquid in "powdered" form.

This is seen as one possible development for a new technique developed by the National Cash Register Co., Dayton, Ohio.

The method calls for liquids to be broken up into droplets of microscopic size, which are then coated with a thin layer of gelatin. Each droplet thus becomes a capsule a millionth of an inch in diameter.

Liquid coffee in "powder" form would retain all its flavor and aroma, it was suggested.

The technique was developed by National Cash Register for business forms that make copies without carbons.

Instant coffee processing in Brazil favored by IBC President Costa Lima

There is no reason why Brazil should not encourage the processing of instant coffee in Brazil.

This viewpoint was stated recently by Renato Costa Lima, president of the Brazilian Coffee Institute (IBC).

It would, he indicated, create new possibilities for reconquering certain markets and create the habit of coffee drinking in countries such as those behind the Iron Curtain.

"How can we," he said, "create the coffee habit in other areas if we first demand that a roasting industry be created. It is much more rational to take the product direct to the consumer as soluble coffee. At the present time, we have only two factories for the production of instant coffee."

The IBC head told a National Coffee Association luncheon in New York City that the Brazilian government is studying ways to give equal treatment to instant and green coffee exports.

During the past year, NCA has protested favorable treatment by Brazil for instant coffee exports.

Pepper growing in Brazil

While commercial production did not start until about 1948, indications are that pepper is well suited to the Amazon Valley. The state of Pará continues to be the principal producer, accounting for over 93% of the total output.

There have been numerous commercial pepper plantings recently in Amazonas, which will take its place soon as Brazil's second most important pepper-producing state.

During 1956, total production in Brazil amounted to 4,500,000 lbs. and increased to 4,800,000 lbs. during 1957. Brazil uses about 2,000,000 lbs. annually, and if the production increase continues, more pepper is expected to enter world trade channels.

Puerto Rico is producing pepper in experimental plots.

STATEMENT REQUIRED BY THE ACT OF AUGUST 24, 1912, AS AMENDED BY THE ACTS OF MARCH 3, 1933, AND JULY 2, 1946 (Title 39, United States Code, Section 233)
SHOWING THE OWNERSHIP, MANAGEMENT, AND CIRCULATION
OF
COFFEE AND TEA INDUSTRIES and The Flavor Field, published monthly at New York, N. Y., for October 1, 1958.

1. The names and addresses of the publisher, editor, managing editor, and business manager are:
Publisher, E. F. Simmons, 106 Water Street, New York 5, N. Y. Editor, Bernard Sachs, 106 Water Street, New York 5, N. Y. Managing editor, None. Business manager, E. Redmond, 106 Water Street, New York 5, N. Y.

2. The owner is: (If owned by a corporation, its name and address must be stated and also immediately thereunder the names and addresses of stockholders owning or holding 1 per cent or more of total amount of stock. If not owned by a corporation, the names and addresses of the individual owners must be given. If owned by a partnership or other unincorporated firm, its name and address, as well as that of each individual member, must be given).
Coffee & Tea Industries and the Flavor Field, 106 Water Street, New York 5, N. Y.; E. F. Simmons, 106 Water Street, New York 5, N. Y.

3. The known bondholders, mortgagees, and other security holders owning or holding 1 percent or more or total amount of bonds, mortgages, or other securities are: (If there are none, so state.) None.

4. Paragraphs 2 and 3 include in cases where the stockholder or security holder appears upon the books of the company as trustee or in any other fiduciary relation, the name of the person or corporation for whom such trustee is acting; also the statements in the two paragraphs show the affiant's full knowledge and belief as to the circumstances and conditions under which stockholders and security holders who do not appear upon the books of the company as trustees, hold stock and securities in a capacity other than that of a bona fide owner.

5. The average number of copies of each issue of this publication sold or distributed, through the mails or otherwise, to paid subscribers during the 12 months preceding the date shown above was: (This information is required from daily, weekly, semiweekly, and triweekly newspapers only.)

E. F. SIMMONS
(Signature of Publisher)
Sworn to and subscribed before me this Eighth day of September, 1958.
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ASTA dinner "breaks bread around the world"

Spice trade publicity for the winter season rolled into high with a United Nations dinner featuring foods and beverages from 25 different nations.

Over 400 members of the spice trade and their guests at the Sheraton-East Hotel, New York City, were given a preview of foods which can be served in homes or restaurants on United Nations Day. The dinner was intended to help Americans "break bread with our neighbors around the world."

The theme for the dinner was developed by the spice trade in cooperation with the United States Committee for the United Nations, which hopes to encourage an interest in other nations through the international language of food, by suggesting that Americans serve foreign foods on United Nations Day.

Officials of the U.N. and the U.S. Committee for the U.N. joined with the dinner guests in sampling dishes whose recipes were secured from U.N. families.

The United Nations Singers, consisting of employees of the international organization, entertained the diners with folk songs in the languages of many nations.

Dishes featured at the dinner were selected by a committee of the American Spice Trade Association, which impartially considered foods of U.N. members. The main dish, Chinese roast duck, has been a traditional food in China for centuries. The duck is at present a mainstay on the island province of Taiwan (Formosa) where the meat provides needed food while the feathers are an important part of the island's expanding trade program. The recipe used in the dinner is flavored with a cinnamon, an ancient spice whose discovery in China by Marco Polo in the mid-13th Century touched off world-wide explorations by Europeans, leading to the discovery of the New World.

The duck's vegetable accompaniments continued the worldwide culinary tour. *In Judias Verdes con Tomate,* from Spain, green beans and tomatoes cooked in olive oil were zested with Spanish paprika. The cultivation of the vivid red paprika has flourished in the Murcia province of Spain since the Middle Ages.

In *pea pulao,* from Pakistan, rice and green peas were enlivened with cloves, black pepper, cardamom and cumin seed. The influence of India and other eastern countries from which the state of Pakistan imports its spices dominates the country's cuisine.

Brandied sweet potatoes, a southern regional American recipe, was a savory illustration of how the aromatic tropical spices—nutmeg, ginger and black pepper—are used to glorify a native vegetable.

The "cold war" was called off when East met West at the American Spice Trade Association's United Nations dinner, given for leading food editors at the Sheraton-East Hotel, New York City. Emphasis was not on politics but on the "universal language," food, and properly seasoned food at that. Among the 430 guests were (from left) George J. Janecek, director of public information for the United Nations; Miss Marina Maslinikov, of the Ukraine (U.S.S.R.), an employee of the United Nations; Miss Olga Jaroskevitch, of Poland, and host William L. MacMillan, ASTA president.

Dinner rolls were *luxe broodjes,* topped with a coating of crispy blue poppy seed. Most of our poppy seed is imported from the Netherlands, where methods of growing and harvesting the seed are preciously guarded secrets handed down from father to son. It takes 900,000 poppy seeds to make a pound.

The entree, Ikan pudding, was a salute to the Federation of Malaya, admitted to the U.N. in September, 1957. A light, custard-textured pudding made with fillet of fish and coconut milk, the Ikan's delicately intriguing flavor is achieved with a subtle balance of turmeric, cayenne pepper, garlic and onion. Malaya's population is composed of Malays, Chinese and Indians, and traditional foods of each of these nationality groups are always seasoned with a spice of the ancient East, such as turmeric. In this fish pudding, as in the dinner's adaptations of other nationaltiy dishes, the convenient American seasoning innovations—garlic and onion powders, or instant minced onion—were substituted

in order to save time and effort for the American homemaker.

Before dinner, ASTA hosts offered an international array of appetizers. Miniature skewers of Moroccan kebabs were pungent with cumin and coriander, which are important Moroccan export spices. There were curry puffs from Ceylon, and cheese biscuit, nippy with dry mustard and curry powder, from Australia.

Cocktail spreads included an Israeli recipe for chopped chicken liver spiked with black pepper and garlic powder, and *körözött*, the cheese-caraway seed spread so popular in Hungary that it is served with any meal and also eaten on rye bread for the midmorning snack.

Sweet basil was the warm, bright flavor accent of a fish and vegetable antipasto from Italy. Basil has been a symbol of love for centuries in Italy, but it has only been since World War II that the American homemaker's romance with the herb has bloomed. Wives discovered its charm when preparing the Italian dishes their husbands had told of enjoying when overseas.

The dinner's first course was *Sopa de Maize*, a light corn soup spiced with whole oregano leaves and black peppercorns. Served with the soup were Euphrates wafers, crunchy and nutty-sweet with sesame seed.

The dessert, *bombe a la menthe*, made with dried mint leaves, was typical of classical French cuisine. The French are great users of herbs and of the *bombe*—a football-shaped ice cream dessert—as evidenced by one edition of a French cookbook that lists 100 different *bombes*.

Interesting flavor and texture contrast to the *bombe* were Norwegian *krumkaker*, paper-thin cookie cones redolent of cardomom and cinnamon, and *galletas de ajonjoli*, Mexican anise and sesame seed cookies.

After the dinner, the food writers were greeted by Howard C. Wolf, chairman of ASTA's dinner committee; George J. Janecek, U.N. director of public information, and Theodore Smith, executive director of the U.S. Committee for the U.N.

The Trianon Room, where the reception preceeding the dinner was held, was bright with U.N. decorations in a fall motif. At the entrance to the reception room was an abstract interpretation of the U.N. symbol made with white plastic "hula hoops," entwined with olive branches.

Named assistant promotion manager

Robert B Anderson has been named assistant sales promotion manager for Thomas J. Lipton, Inc., Hoboken, N. J.

Mr. Anderson started as a saleseman and was transferred to sales promotion more than three years ago.

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New way to tell where nutmeg or mace originated developed by USDA, ASTA

The area of origin of nutmeg or mace can now be positively identified by new methods of analysis developed by the U. S. Department of Agriculture in conjunction with the Research Committee of the American Spice Trade Association.

The measurement of the phenol content in nutmeg or mace oil, either by spectrophotometry or paper chromatography, has been found to tell accurately whether the spices come from the East or West Indies. These are the two main growing regions, and because of price and quality differences, it is important to have a reliable method of distinguishing the sources.

The research was carried out by the USDA's Agricultural Research Service as part of a collaborative analytical research program with the American Spice Trade Association.

Both methods of analysis test the dyes derived from coupling the phenols in nutmeg or mace oil with a diazonium salt. The spectrophotometric analysis is the faster of the two procedures; however, paper chromatography has the advantage of requiring only simple, readily available apparatus.

The results are found to be equally good with either spice because of their close relationship. Nutmeg comes from the kernal of the nutmeg fruit, while mace comes from a lacy aril which surrounds the kernel.

Flavor symposia now available in book form

Independent studies in flavor research have been going on for the past decade in widely scattered areas. To centralize and integrate the results of these separate studies, the Arthur D. Little Flavor Laboratory sponsored four symposia in 1956 and 1957.

These symposia covered (1) the bases and importance of taste and smell; (2) the chemical constitution of flavor; (3) market research on consumer wants; and (4) methods used in sensory flavor analysis.

Over 40 leading researchers in these areas presented their findings.

This information is now available in a book, "Flavor Research and Food Acceptance," which integrates the various aspects of the subject and presents them in perspective.

Published by the Reinhold Publishing Corp., New York City, the 397-page book is $10 a copy.

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AGENTS AND BROKERS IN

SPICES SEEDS TEAS COFFEES

67 California Street San Francisco 11, Calif.

San Francisco Samplings

By MARK HALL

■ ■ How is the coffee market? We're told that what was said 30 days ago could be repeated. Prices have fluctuated within a narrow range. What strength was shown at times might be attributed to the scarcity of Centrals at this time of the year.

A hopeful sign, at least to the steamship company bringing in the coffee, was the load of 58,425 bags on the Mormacrey for the Pacific Coast. This is reminiscent of better times for Brazilian shipments. These are 389,466 bags behind in the first ten months of this year, compared to the same period last year.

The market seemed to be trying to close the gap between spots and December futures, at least for the delivery period. Beyond December, the futures market indicated a lack of confidence, and opinion is that anything could happen.

At the time of this writing, Centrals are beginning to be offered. Indications are that these offers will be made at attractive prices. New crop Centrals for forward shipment are being made at prices below comparable Brazils. As time goes along, pressure from this source should increase.

Trading by roasters is pretty good, steady, and on a hand-to-mouth basis. It is difficult for the broker. He is caught in a falling market with a small brokerage fee, and with the value of a pound of coffee at only half of what it was some time back.

Africans are weak, but local opinion is that this is due to European lack of demand. Colombians have been more steady, for at this time of the year they have the market much to themselves. They are the only source of large volume milds.

■ ■ There was a riot of local talent at the October golf and banquet meeting of the San Francisco Coffee Club, at the Claremont Country Club, Oakland. After a meeting like this, it seems that the professional entertainer cannot compete. As at all good coffee conventions, telegrams had to be read as an opener to the program.

Bob Manning took the place of Jack Schimelpfenig as master of ceremonies for the opening of the program. Brother Ed Manning acted the messenger boy and rushed in with a special wire from the Associated Press. It reported Jack had been appointed president of the IBC. He had a new scheme to bolster Brazil's economy. The plan called for devaluing commissions to green coffee brokers. Jack should be one of the most popular men in Brazil, if not in local green circles.

Manning Rosen next announced that he felt coffee men needed more culture and that the Club had engaged the Mexican Coffee Bean Quartet to play a few south-of-the-border classics. John Cognetta, L. E. Binsacca, Bob Manning and Ronald Garrigues did their stuff on a variety of instruments made of bailing wire, scraps of paper, sticks and tin cans. The weird melodies resulting were new in the musical world. From the response of the audience, culture went over in a big way.

THE BUSINESSMEN AND THE PROFESSOR
By Mark Hall
See
"Mark my word"
on Page 138

Another feature that took the house by storme was a contest to see who could whirl hoops the best. Ernie Shaw perspired and wiggled but the hoop would work down to the floor while Ernie he was still doing the hula. Then he took off his coat and started with the hoop around his neck, but as usual, it came to rest at this feet. Whirling hoops is only for the very young. Bill Fenerin, in the same contest, won the coveted bottle.

In golf, low gross was won by Jim De'Armond wih 77; low net, 63, by Tom Barrett, who grossed 82; lows for guests, Ross McIntyre, gross and Norm Montano, net; blind bogie, John Beardsley and Lyle McKim. Neal Hopping won the booby prize.

Fred DeBow was elected a director to succeed Jack Schimelpfenig. Chairman for the evening was Manning Rosen, with Fred DeBow as co-chairman.

The next meeting will be December 12th at the California Country Club.

■ ■ R. C. Pauli & Sons have sold out to Durkee Famous Foods, division of the Glidden Co. The old firm name will exist no more. Harold E. Pauli and Tom C. Pauli will continue with the spice operation in Durkee under Richard Hauer, general division manager.

While Durkee did some spice business here, the bsorption of the Pauli firm will give them facilities for grinding and packaging, as well as a greater spice operation. They must forfit the old location by the first of the year.

■ ■ Next years convention of the American Spice Trade Association will be held at the Del Monte Lodge, Pebble Beach. The Northern and Southern California committees of the association will collaborate in acting as hosts to the members.

■ ■ Harvey Brockhage no sooner got home last month from a trip to Mexico than Norm Johnson flew there himself.

■ ■ Leslie Gray, of Brooke, Bond, Ltd., London, was an October visitor in San Francisco. He was on his way home from the Canadian tea convention. He was accompanied by Mrs. Gray. While here, he visited Ed Spillane as well as other members of the trade.

■ ■ The Tempo-Vane Manufacturing Co. is continuing as usual since the death of Louis Ozor, its founder, August 31st. Jo Stonum, son-in-law of Louis Ozor, who was president, is continuing in the same capacity as the active management of the company.

The company is cutting grinders, building automatic bag feeders, scales and automatic tuckers and sealers.

Louis Ozor was with Mill Engineering, in Oakland, before establishing his own business. Prior to that, he was the engineer for Schilling for many years.

■ ■ Jack Sassard, advertising manager of the Schilling division of McCormick & Co., was the featured speaker at the monthly luncheon of the San Francisco chapter of the Sales Promotion Executives Association.

(*Continued on page 169*)

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New York News

■ ■ Front Street now has a lady coffee taster. She's Miss Justina M. Bird, a comely Brooklynite, who has been named manager of the New York office of the Woolson Spice Co. Announcement of the appointment was made by Nate L. Schmid, Woolson president.

Miss Bird becomes the first woman to hold a top executive position with the firm. She's one of the very few women to hold such a post in the industry.

As head of Woolson's New York office, Miss Bird supervises the purchase of green coffee for Woolson plants in Brooklyn, for the Toledo, Ohio, headquarters plant and for the Woolson subsidiary, the Jas. H. Forbes Tea & Coffee Corp., St. Louis.

She also supervises sales of coffee, tea and spices and the company's instant coffee operations for New England and the New England and Atlantic Seaboard areas.

Miss Bird has been with Woolson for the past 16 years.

■ ■ Renato Costa Lima, president of the Brazilian Coffee Institute, was host last month at a luncheon in New York City for National Coffee Association officers, directors and advisory committee members.

The IBC head said that the Brazilian government is studying ways to give equal treatment to instant and green coffee exports. During the past year, NCA has protested favored treatment by Brazil to instant coffee exports.

He also said that Brazil was still studying the possibility of a guarantee in the event of devaluation of the coffee cruzeiro.

■ ■ Members of standing committees in the New York City Green Coffee Association were named last month at the organization meeting of the board of directors.

The committees, and the people appointed to them, are as follows:

Finance and Executive: W. H. Lee, chairman, H. F. Baerwald, A. L. Ransohoff.

Contract: E. J. Walker, chairman, C. F. Corey, C. S. Mackey, P. Ritter, J. F. Smith.

Traffic and Warehouse: R. A. Sutherland, chairman, F. P. Burnham, R. Hechko, C. P. Monahan, S. E. Newhoff.

Membership: E. B. Ackerman, chairman, J. H. Coleman, J. F. McCarthy.

Arbitration: H. R. McComb, chairman, J. Delay, H. A. Fraenkel, H. Horwitz, J. A. McMillan, C. T. Ney, S. B. Willey.

By-laws: C. Leister, chairman, M. C. Densen, W. L. Korbin, Jr., J. J. Schwartz, D. A. Sperling.

Spot Quotation: F. Kohn, chairman, T. J. Mangieri, H. R. McComb, J. A. Sim, P. L. Stetzer.

Activities: F. E. Barnard, chairman, D. Fletcher, R. H. Kolm, J. J. Malone, F. Schoenhut.

Standard Type: J. G. Cargill, chairman, J. W. Finnerty, E. K. Klaussmann, Jr., J. P. Norton, L. Schlesinger, H. F. Sneden, R. H. Sues, P. Zimmerman.

■ ■ In New York last month was a dynamic visitor from Australia, Marshall Gibson, managing director of Gibby's Coffee Shops Pty., Ltd.

Gibby's has been instrumental in starting a trend down under to better quality coffee, Mr. Gibson reports.

He was here as part of a two-month visit which will also take in other East Coast cities, Washington, D. C., and the West Coast.

He is studying coffee processing and retailing, management methods in chain coffee shops, coffee shop equipment and packaging techniques.

During the last three years, coffee demand in Australia has shifted drastically, Mr. Gibson reports.

Before, demand was entirely for low grade ground coffee and chicory mixtures. Now different blends of real coffee of a far better quality are available.

Sparking this trend was a Gibby's coffee shop which sold both the beverage and the bean. It was a source of advice on home brewing, and became famous as a "good coffee" center.

Iced coffee, Mr. Gibson notes, is in great demand in Australian restaurants.

To prepare it, black coffee made from instant is refrigerated. Ten per cent cream is added, two balls of ice cream are dropped in, and the Australian customer has iced coffee—at 15¢ a glass. (This price, incidentally, compares with 10¢ for regular hot coffee.)

Espresso coffee shops have also sprung up, helping the trend.

A big handicap to carrying the quality boom further, Mr. Gibson comments, is the fact that Australia is unable to get Latin American coffees.

■ ■ Joseph B. Martinson, president of Jos. Martinson & Co., Inc., has been named chairman of the coffee division in the 1959 New York March of Dimes campaign.

The expanded program of the National Foundation includes virus diseases, arthritis, birth defects and disorders of the central nervous system, in addition to polio research and patient aid.

Arthur G. Dunn, president of Arthur G. Dunn & Co., is chairing the drive for the spice division.

■ ■ Dick Balzac, vice president of Balzac Brothers & Co., Inc., has been named chairman of the coffee division in the 53rd annual appeal of the Travelers Aid Society of New York.

Travelers Aid gives confidential help, free of charge, to anyone in trouble away from home. Its presence at the airports, piers, railroad and bus terminals averts many tragedies.

■ ■ Eddie Conran, retiring from the Tea Examiner's office after many years, was honored at the fall meeting of The Tea Club, informal organization of members of the trade in the New York area.

One of the best turn-outs yet, about 125, indicated the widespread regard for Eddie in the trade.

Tom Shea, outgoing Tea Club president, read many telegrams wishing Eddie well in his retirement.

The Club itself gave him, as indications of its esteem, a power mower and a standby electric generator for the new home the Conrans are building in Pennsylvania, near Valley Forge.

In a short business session, the Club elected Tom Dannemiller president of the coming year.

Other officers named were Bill Congalton, vice president: Elaine Kroner, secretary; and John McCarthy, treasurer.

The newly elected treasurer was not present. The reason? He had just become the father of twins.

■ ■ A. N. Baldwin, representing Alex. Lawrie & Co., Ltd., London, arrived in New York last month on the Queen Mary.

While here, he made his offices at the company's agents, George C. Cholwell & Co., Inc.

After a visit to Canada, he returned to London aboard the Queen Elizabeth.

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New Orleans Notes

By W. McKENNON

■ ■ Members of the trade who attended the Southern Coffee Roasters Association meeting at the Hotel Peabody, Memphis, included: Adolph Ricks, Adolph C. Ricks & Co.; Tom Buckly, Buckly and Forstall; Albert Schaaf, Stewart, Carnal & Co., Ltd.; James J. Meyers, Oulliber Coffee Co.; Albert Barrientos, Westfeldt Bros.; Louis Castaing, Leon Israel & Bros., Inc.; Ed Lafaye, Edmond Ganucheau and William Maderi, J. Aron & Co., Inc.; Mr. and Mrs. George V. Foltz, Foltz Tea & Coffee Co.; Mr. and Mrs. Ralph Richards, Otis McAllister Co., Ltd.; Ed Bent, Mississippi Shipping Co.

■ ■ The funeral of J. Harold Schneider, traffic manger of J. Aron & Co., Inc., who died of a heart attack was held here with religious services at St. Dominic's church and interment in St. Vincent de Paul Cemetery No. 1.

Mr. Schneider, 59, was a member of the Traffic Club of New Orleans, the Propeller Club and the Export Managers Club.

He is survived by his widow, a son and three grandchildren.

■ ■ C. A. McEniry has been appointed executive vice president and general manager of the Waterman Steamship Corp. of Puerto Rico, as announced by J. K. McLean, president of the corporation. Mr. McEniry was formerly district manager for Waterman here. He will be succeeded by Walter F. Williams, former foreign service manager.

■ ■ W. C. Englisbee, of Ruffner, McDowell & Burch, Inc., was a recent business visitor in New Orleans. He stopped here enroute to New York from a visit to Mexico, El Salvador and Guatemala.

■ ■ The annual golf and gin rummy outing of the New Orleans Green Coffee Association was held at the Lakewood Country Club. First prize for golf went to G. C. Gernon, of Ruffner, McDowell & Burch, Inc. The first prize for gin rummy was awarded to Ed Sander, of Blue Plate Coffee.

Door prizes were also distributed, at the dinner following the afternoon's contests.

■ ■ A. C. Cocke, vice president of the Lykes Brothers Steamship Co., Inc., has been named chairman of the new American Steamship Committee on Conference Studies.

The committee was formed to coordinate activities of the American steamship industry and to lend cooperation to pending congressional studies of various steamship conference and dual rate systems. Ex-officio members named are H. A. Carlys, chairman of the Gulf Associated Freight Conferences, and Fred D. Hill, chairman of the Gulf and South Atlantic Steamship Conference.

■ ■ Two of the busiest attractions of International Week here, October 12th-18th, were the sidewalk cafe of the National Federation of Coffee Growers of Colombia at Canal and Elk's Place, and the sidewalk cafe of the Guatemalan government at Canal and St. Charles Avenue.

Both cafes served free coffee to visitors in their gaily decorated enclosures, set with tables and chairs.

■ ■ The Green Coffee Association of the New Orleans Bowling League has announced that the Mississippi Shipping Co. is first high team, three games at 2252; Dupuy Storage and Forwarding Company league is second, three games at 2191; Westfeldt Brothers league third, three games at 2183. Mississippi Shipping Company rolled the high team game, 825; S. Jackson & Son league tied with Biehl & Co., both scoring 776.

First high game was chalked up by Mississippi Shipping's Elroy Tedesco, 219; second high individual game, Harold Lemonier, S. Jackson & Son, 207; third high individual game, Joseph Bennett, Kentucky Warehouse, 204.

High individual for three games was Karl West, Dupuy Storage & Forwarding Co., 526; second, Harold Lemonier, 521; third, L. E. Dittmer, 513.

St. Louis

By LEE H. NOLTE

■ ■ The golf season of the St. Louis Coffee Club wound up with a big bang, but not so much on the subject of golf.

The occasion was a salute to the Old Judge Coffee Co: on its 100th anniversary. There was an unusually good attendance, and of course, Old Judge was well represented. Their resident manger, Carl F. Hull, was presented with a very lovely plaque by Roy Ruhl, of the Star Coffee Co., on behalf of the St. Louis Coffee Club. Mr. Hull gave a very fine acceptance speech.

J. L. Brennan, of Old Judge, said that just 108 years ago his grandfather purchased a 300-acre farm located in what is now the heart of St. Louis for the large sum of $60.00—not per acre but for the whole parcel.

As usual, there were atractive attendance prizes for everyone, and the club served a delicious roast beef dinner.

Again, our chairman Gene Crowson, did a fine job.

Our young president, Ed Koch, presided at the meeting Ed, by the way, happens to be coffee buyer for Old Judge.

■ ■Louis M. Antoine, a St. Louis coffee merchant for more than 50 years, died recently of a heart attack at his home. He was 84.

Mr. Antoine entered the coffee business here shortly after the turn of the century, with the old Athletic Tea Co., and later was associated with Antoine Brothers Tea and Coffee Co. He retired several years ago.

He is survived by a son, Louis H. Antoine, insurance executive and member of the St. Louis Board of Education, and a daughter, Mrs. Martha J. Barnes, with whom he lived.

Southern California

By VICTOR J. CAIN

■ ■ Don Harvie, manager of Hard & Rand, Inc., San Francisco, recently came to Los Angeles to make all final arrangements for moving his family to San Francisco.

■■ Alan Bories, assistant vice president of J. Aron & Co. New Orleans, was in town calling on the local coffee roasters.

■ ■ Beck Rowe, of E. A. Johnson & Co., San Francisco, visited Los Angeles to call on the coffee roasters located in Southern California.

■ ■ Mr. and Mrs. Walter Dunn, of the Dunn & Cain Co., Los Angeles, green coffee brokers, spent a weekend in Palm Springs.

■ ■ William T. Moore, president of the Moore-McCormack Lines, Inc., accompanied by Frank M. Bower, vice president, stopped in Los Angeles to look over the shipping situation in Southern California.

■ ■ Jack Horning, of the Tenco Corp., soluble coffee processors, was in Los Angeles calling on the coffee roasters.

■ ■ Charles Nonenmacher, formerly of the Jewel Tea Co., Inc., has been appointed agent here for the Sol Cofe Manufacturing Corp., of New York City.

■ ■ Don Dunn, of Haas Bros., San Francisco, stopped off at Los Angeles to call on the local coffee roasters.

■ ■ Roy Farmer president of the Farmer Bros. Co., went on a hunting trip to Oregon. From all reports, there was plenty of game.

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At the October golf and dinner meeting of the San Francisco Coffee Club (from left): Chuck Cecil, Dick Wilcutt, Slim Fowler, John Roddy, John Cognetta, Manning Rosen, Bill Edgar, Olin Howell, Jim De Armond, Gene Heathcote, Bill Hughes, Jack Hornung, R. E. Fitzgerald and Bob Powell. "After a meeting like this," comments Mark Hall, "professional entertainers cannot compete."

San Francisco

(*Continued from page 165*)

■ ■ Jack Leach, of the Coffee Brewing Institute, gave demonstration before the local coffee men which was very well attended. Jack had a much better chance to get his story over at the Commercial Club than he did at the PCCA convention, where other distractions were too great.

He outlined the requirements for good coffee, and coffee men verefied his findings by tasting the results of the good and bad way of brewing restaurant coffee. He said that most coffee on the Coast is brewed at the rate of three gallons to the pound, and that will not produce good coffee. Bitterness is often confused with strength in the brewing of coffee, he pointed out.

Jack seems to be in great demand to make these demonstrations, and he has a hard time fulfilling engagements. On September 20th, TV station KOTI, of Klamath Falls, Oregon donated 15 minutes for a coffee demonstration, as a public service.

At the Canadian tea and coffee convention in Victoria, another demonstration was made, which was highly regarded by the Canadians.

Seattle's TV station, KING, devoted seven minutes on its "Telescope" program to Jack demonstration. This had been arranged by the M. J. B. Co. as a service to the industry. They were not the sponsors, however. In Los Angeles, Jack put on a demonstration for the Restaurant Association.

Among the many attending the Canadian tea and coffee convention from the states and attending these demonstrations were Weldon Emigh, Tom Duff and Carl Kemp.

■ ■ At the last meeting of the Western States Tea Association, the group was honored, as well as entertained, by Tom O'Rourke, of the Aldine Paper Co. Tom is not unknown to San Franciscans, having at one time lived here. In the meantime, Tom has been growing. He is now on the senior board of directors of the Tea Association, and was chairman of the convention of the Association held at Lake Placid's Whiteface Inn. The reason for the timing of his visit was that he was on his return from the Canadian tea and coffee convention, at Victoria.

Tom is a keen observer and has a good memory. He outlined to the local tea men many of the discussions and ideas which were brought up at the Canadian convention. He said that Canada is now using tea bags for 52% of its consumption, which runs about 42,000,000 pounds annually.

He discussed the relative position of instant and leaf tea, their position in the restaurant business, and what could be done to promote consumption. It was felt in the trade that sooner or later a relation would be established between the consumption of instant and leaf tea and this would remain more or less static. The same could be said for coffee.

■ ■ The WSTA picnic was held at the San Mateo Memorial Park. During that

CBI's Jack Leach

month, the Bay region enjoyed a stretch of warm weather, and the day of the picnic was one of the finest. There was a good crowd, not up to previous years, but there were plenty of kids.

The horseshoe game, always one of the most hotly contended was won by Jim Mahoney, Jr., and Stanton Lee. Jack Sassard and Ray Graham cooked the hot dogs and did a good selling job in their distribution.

Stanton, handling the kids' games, saw to it that every one got a prize. Charlie Montague kept the boys and girls from getting thirsty, while Larry Meyers called the bingo game.

Ed Spillane was there with flying colors, it being his first appearance after a sojourn in the hospital.

■ ■ Moore-McCormack's freighter Mormacrey, docked in San Francisco last month with a coffee cargo of 58,425 bags from Brazil. This was the largest load of coffee for the Coast since 1957. The company hopes that with this shipment regulations and quotas in Brazil will be such that shipments in volume will continue.

The Mormacrey is under the command of Captain H. Allen and is one of seven express freighters operating between the east coast of South America and the U. S. Pacific Coast.

■ ■ Among coffee and tea men recently released from hospitals are Ed Jhonson, Sr., Jack Mooney, Ed Spillane and John Siegfried.

■ ■ John Pollaro is now with the Stewarts Private Label Coffee Co., Chicago. The company does custom roasting and puts out a brand of its own.

Minneapolis

By HARRY P. RILEY

■ ■ For the second straight year the 1958 Upper Midwest Hospitality Exposition—"UPS" for short—was held in the Minneapolis Civic Auditorium Minneapolis. There were 116 exhibitors from five states, including Minnesota, North and South Dakota, Wisconsin and Iowa.

Four Twin City coffee roasters were represented, including the McGarvey-Atwood Coffee Co., Nash Coffee Co., Eibert Coffee Co., Continental Coffee Co. of Chicago, and Maxwell House. Attendance was just a trifle under 3,000.

Coffee brewing techniques were demonstarted by Warren A. Schmidt, field representative for the Coffee Brewing Institute.

"To Make Eating Out More Pleasurabl eand Less Expensive" was the theme of the exposition.

Registrants from the five states viewed the newest mechanical devices for preparing and serving foods. Under restaurant consultant George F. Wenzel, they studied ways to improve the quality of their foods while upping profits to the same time.

Java flowed like water from the founts of a dozen coffee dealers and half as many firms exhibiting equipment to dispense the brew.

The convention lasted three days and indications are that it was a tremendous success.

Named chairman

N. F. H. Fleming, manager of tea buying and blending for Thomas J. Lipton, Inc., has been named chairman of the tea division in the 1959 New York March of Dimes campaign.

Mr. Fleming said: "Funds are urgently needed to support the new and expanded program of the National Foundation."

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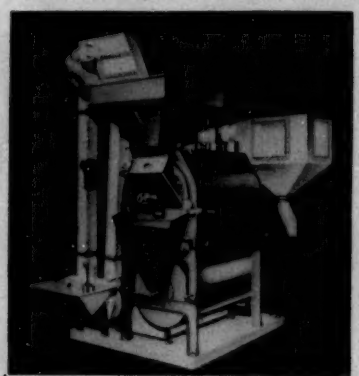

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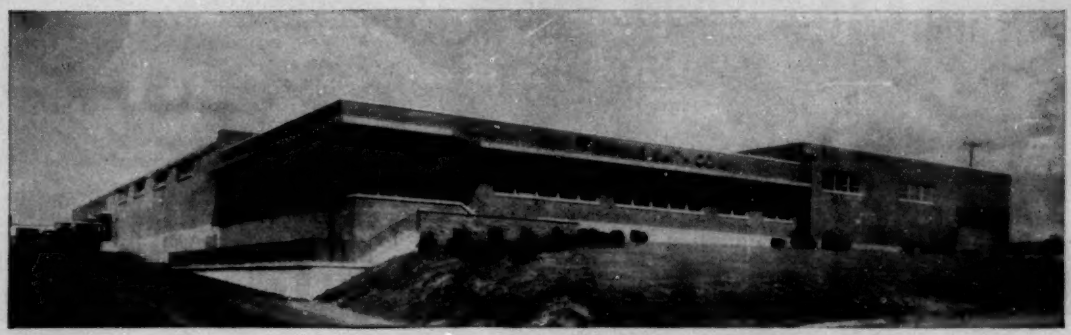

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